

Astronomiae Instauratae Progymnasmata

Introductory Exercises Toward the
Restoration of Astronomy

(1610)

by Tycho Brahe (1546–1601)

Translation by Scott Weisman



ARS ASTRONOMICA

2026

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Published by [Ars Astronomica](#)

Translator Version 2

Upright reason dictates that the recipients of the good, of whatever type and level of beneficence it may be, must show gratitude and blessing to the beneficent person in every way possible, commensurate with the value of the beneficence. And one who has benefited all the people of the world — for example, one who invented a new instrument for the good of the world, or a good book — it is fitting for every discerning person, out of the obligation of love of fellow beings, to at least purchase it, so that the man will profit and his heart will be encouraged thereby to invent yet more good instruments in the world. And similarly, all other wise-hearted people will likewise strive and exert themselves to invent good things and instruments needed for the repair of the world and its perfection.

And therefore, whoever says: "What do I need this new instrument for?" — he does not act well towards the world. For if not for the man who invented it, where would you be? And what would your city do? And more than this, if the man did not exert himself, what would the world do?

— R. Pinchas Eliyahu Hurwitz, *Sefer HaBris HaShalem* (1797)

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A note on the work

The fullest statement of the observational program that transformed the science of the heavens. It reconstructs the motions of the Sun and Moon with unprecedented accuracy, presents the most precise catalog of fixed stars ever compiled without a telescope, and gives a sweeping account of the brilliant new star of 1572 — proof that even the supposedly changeless heavens could give birth to something new. Left unfinished at its author's death, it was carried to publication by Johannes Kepler, who added an appendix of his own. It is one of the great monuments of the scientific revolution.

Translated from the copy of the 1610 Frankfurt edition held by the ETH-Bibliothek, Zürich (Rar 4153) and digitized by e-rara. An earlier copy was collated first, but it proved to be misbound in two places and to be missing four leaves; this copy is sound throughout and supplies the passages the other lacks.

A note on the translation process

This translation was produced with the [translation-pipeline](#). See the linked repository for details on the process.

This text is the product of a highly refined automated translation process. It has undergone only cursory human review and should not be treated as an authoritative or scholarly rendering. It is offered solely as a reference and reading aid — a way to make an otherwise inaccessible work approachable — and any passage of real consequence should be checked against the original source.

Acknowledgements

Translated with the assistance of Claude. The translator thanks the [Anthropic](#) team for making this work possible.

Astronomiae Instauratae Progymnasmata — Front Matter

[Binding: front cover]

No printed or manuscript text is present on the cover.

[Inside front cover (front pastedown)]

The pastedown carries modern library shelfmark and inventory annotations in pencil and crayon, plus the ghost (show-through) of a small pasted label.

- [Margin: upper left, pencil] "1393 (Rar)"
- [Margin: upper left, pencil, struck through] "[?]" [an earlier shelfmark, partly erased/cancelled — illegible]
- [Margin: upper left, pencil] "Rar 4153"
- [Margin: center, red crayon, large] "8664-65"
- A small rectangular paper label is pasted at center; its printed text is visible only in faint reverse show-through and cannot be read. [Illegible: pasted label, reads through verso only]

These are all library/cataloguing marks of the holding institution (ETH Zürich / e-rara exemplar), not part of the printed work.

[Flyleaf (recto)]

Blank flyleaf. A single faint pencil mark appears near the top center:

- [Margin: top center, pencil] "W" [a check-mark or initial; followed by a short dash]

At the outer (fore-edge) margin there is faint offset/show-through of italic text from a facing leaf — individual letter-fragments only, not continuously readable:

- [Illegible: fore-edge offset, italic fragments — "...a /...n /...lice... /...stig... /...por... /...ae /...co..." — show-through from an adjacent page, not original text on this leaf]

No original printed text is present on this leaf.

[Flyleaf (verso)]

Blank flyleaf verso. No text or printed matter; only paper foxing and staining. The printed title page has not yet begun.

Title Page

[The title page is printed in two colors, red and black. In the transcription below, the color of each element is noted in brackets. Hand-written annotations by a former owner appear in the right margin and are transcribed separately.]

[Red:] TYCHONIS BRAHE DANI, [Tycho Brahe the Dane's]

[Black:] ASTRONOMIÆ INSTAURATÆ PROGYMNASMATA. [*Preliminary Exercises Toward a Restored Astronomy*]

[Red:] Quorum hæc [Of which this]

[Red:] PRIMA PARS [FIRST PART]

[Red:] DE RESTITUTIONE MOTUUM [Black:] Solis & Lunæ, Stellarumque inerrantium tractat. [treats OF THE RESTORATION OF THE MOTIONS of the Sun and Moon, and of the fixed stars.]

[Red:] ET PRÆTEREA DE ADMIRANDA [Black:] noua Stella Anno 1572. exorta luculenter agit. [AND BESIDES, it gives a full account OF THE REMARKABLE new star that appeared in the year 1572.]

[Red:] ANNO **[Red:] M. DCX.** [In the year 1610.]

[Red:] Excudi primum cœpta Vraniburgi Daniæ, [Black:] ast Pragæ Bohemiæ absoluta. [Begun to be printed first at Uraniborg in Denmark, but completed at Prague in Bohemia.]

[Black:] PROSTANT [They are on sale]

[Red:] Francofurti apud Godefridum Tampachium. [at Frankfurt, at the shop of Gottfried Tampach.]

[Black:] Cum Cæsaris & Regum quorundam priuilegiis. [With the privilege of the Emperor and of certain kings.]

[Margin: Two sets of hand-written marginalia by a former owner appear at the right. Upper note (giving coordinates, likely of Uraniborg/Hven): "Marburgi [?] /

Longit. 36 41 / Latit. 55 55" — i.e. longitude 36° 41', latitude 55° 55'. The placename reading is uncertain.]

[Margin: Lower note, in a cursive hand: "Exemplar hoc est completum, utpote Tomo III. Epistolas Brahei, cum Effigie Authoris, topographia Insulae Huennæ, Uraniburgi, instrumentorumque Astronomicorum aeri incisus continens. Accedit, quod doctus et industri[us] [?] possessor aliquot errata per omnes tres Tomos in fine excusa, sedulo calamo cor[r]exerit." — "This copy is complete, inasmuch as it contains, in Volume III, the *Letters* of Brahe, together with the Likeness of the author, a map of the island of Hven, of Uraniborg, and of the astronomical instruments engraved on copper. It is further noted that a learned and diligent [?] owner has carefully corrected with his pen several errata, printed at the end, throughout all three volumes." (Reading of a few words uncertain.)]

[Title-page verso — blank]

[The verso of the title leaf is blank; only show-through (offset) from the printed title page on the recto is visible.]

Dedication

TO THE MOST AUGUST EMPEROR RUDOLF II

The Preface of the Heirs of Tycho Brahe [Heredum Tychonis Brahe Praefatio]

This posthumous work [opus posthumum], most August Emperor, we now set before the gaze of Your Sacred Imperial Majesty, and we dedicate it to your renowned name: the *Astronomical Preliminary Exercises* [Progymnasmata] of our father, of pious and praiseworthy memory. Yet these have grown, little by little, into so great a mass of material that they convey to posterity far more than the bare title of *Progymnasmata* promises. For if ever the Horatian rule [Horatiana lex] has been observed anywhere with particular care, it has certainly been so in this volume, a book now held back into its third nine-year span.

[Margin: 7] [Margin: 17]

Our father had at first resolved to treat in this book only of that remarkable new star of the year [15]72, and to examine the opinions of others concerning it; and this work he committed to his own press at Uraniborg, the undertaking advancing gradually and as the Lord allowed. So it came about that in the meantime he carried out, step by step, not only the precise restoration of the

Sun's course, but also the fixing of the positions of the fixed stars to within a single minute — indeed to half that, both in longitude and in latitude — and finally the unraveling of the Moon's most intricate motion. And to this volume he added so much that we can truly affirm that this book has earned, by the dignity of its material, not the title of *Astronomical Progymnasmata* but a far loftier one. How deeply hidden this subject is, and therefore how laboriously it had to be drawn out, and how vainly it was pursued through all past ages by various and indeed the greatest masters [Artifices] — we leave for those to weigh who have tasted of astronomy even with the tips of their lips.

[Margin: 30]

This incomparable labor — and the ill-will of the malicious, which was far greater still — our father devoted to Your Sacred Imperial Majesty, dedicating to it all his studies in the final years of his life. Now at last, after he has ceased to be among the living, we, his surviving heirs, offer this work, finished by the press, to that same Majesty. And we do so with this purpose: both to render an account of his studies before the foremost Monarch of the Christian world, and to cut off from the envious every handle for slander.

[Margin: 40]

Those slanderers were stirred up against him while he yet lived — whether by an itch of wickedness, or by corrupt characters, or driven crosswise from the true path of judgment by ignorance — so that they reckoned as wasted whatever was spent upon these royal disciplines (a sum which, in view of the dignity and glory redounding from them, and indeed of the necessary expenditures, was very small). But this complaint of ours is one we share with all learned Heroes of every age, whom envy has never abandoned except after their deaths. So true is it that in no age have there been wanting men like Aristippus [Aristippus] and Epicurus [Epicurus], who scorned the mathematical disciplines as useless, and who therefore pursued their practitioners with a hatred more than barbaric.

But in truth, MOST AUGUST EMPEROR, upheld by the imperial authority of Your Majesty,

[Continuation of the heirs' dedicatory preface to Emperor Rudolf II.]

upheld by that imperial authority which, set on the highest summit of dignity, has lifted its head far above the rest of mortals — we would be foolish indeed if we paid the slightest regard to two-legged creatures of this sort. [Margin: 60] On the contrary, we value such futile censures at not one penny, and we set before our

eyes the very examples of Your Majesty's ancestors — of Alphonso, king of Aragon and Castile [Alfonso X of Castile], of both Alberts of Austria, of Frederick, of Charles V, and the like — who supported this royal pursuit in the highest degree and rewarded its diligent practitioners munificently. For what, indeed, was more magnificent in King Alphonso (to bring forward one example out of many) than that he spent more than four hundred thousand ducats — with a generosity, by Heaven, [Margin: 70] worthy of praise and proclaimed by all posterity — upon the Alphonsine Tables of the celestial motions [Tabulae Alphonsinae]? Surely the Aristippuses of our own age would have judged this far more rightly spent had he laid out a still larger sum upon sordid and frivolous things. But these good men fail to notice that for Alphonso an everlasting glory has now been won, coeval with the world, while the fame of the other kings of that age has long since been buried and lies hidden in oblivion. And yet these Tables, purchased at such cost — good God, how defective they still are, how mutilated! How utterly incomparable to the labors of our own Parent, L. M.! How enormously they are sometimes found to stray [Margin: 80] and wander from the celestial track! Nor is this any wonder, since the makers of the Tables did not bring even a single celestial observation to bear in their reckoning, but, comparing the observations of the ancients among themselves, confining themselves to these, and noting the progress of the stars only as best they could, they attained such precision as they were able — not such as they ought — and stitched together this jumble of a Table.

This deficiency, however, certain distinguished men have from that time onward tried to remedy — men equal indeed in talent to bearing this burden, [Margin: 90] but unequal in resources. Foremost among them was that great and never sufficiently praised Nicolaus Copernicus of Toruń [Nicolaus Copernicus]; yet even he — whom, as we said, the same scarcity of observations and instruments that hindered the Alphonsines hindered too — could not as yet attain all that he wished, although his restoration of the motions does not depart so very far from the celestial standard as that of his predecessors.

[Margin: N3 (?)] Therefore we declare, with confidence indeed, but with modest restraint, that our Parent surpassed by a long interval all the astronomers from the founding of the world (so far, that is, as their writings have reached us) [Margin: 100] in restoring the motions with singular accuracy; and that none of the kings and princes — not to say private men — after King Alphonso spent so much and so greatly upon astronomy. For he laid out upon these studies not only everything that he could scrape together from the fiefs and benefices which, in truth, he held in fullest abundance from the renowned Frederick, king of the

Danes [Frederick II of Denmark], on account of the splendor of his lineage and his love of astronomy, but also, from his own private purse, more than a hundred thousand thalers.

[Margin: 110] But when, after the death of that most praiseworthy king, his resources seemed nearly exhausted, he was summoned here from his homeland by Your Majesty's most gracious decree, and devoted himself to this one task: that he might as soon as possible unfold to mortals the Tables of the celestial motions — the RUDOLPHINE Tables [Tabulae Rudolphinae], far more perfect than the Alphonsine and the Copernican — and that

astronomy, through the generosity of Your Majesty, which had freely promised to provide for it at our Parent's expense, might live forever through astronomy; when, behold, God, in the very vigor of his age and of his work, with great grief to the Republic of Letters [Margin: 120] and with irreparable loss to his heirs, took him away from mortals.

But setting aside this lamentation — since this fatal calamity has befallen astronomy — we judge that what now belongs to our duty is this: that provision be made for Posterity, of whom we must take account first of all. We beseech Your Majesty, by God immortal and by the holy rites of Urania [Urania], not to neglect the palm of everlasting praise that has been set within reach, amid these tumults of war, but by your own authority and at your expense to press forward the completion of those Tables — a task most worthy of an Imperial Majesty. "Let there be patrons; [Margin: 130] the Flacci and the Maros will not be wanting," as the poet used to say. Let there be Alphonsos, Alberts, Fredericks, Charleses, and there are not, nor will there be, lacking men who will take up this Province with eager spirit (since the chief foundations of the matter have now been laid) and, within a few years, complete whatever remains — which is truly little. If anyone can or should propose a transient fruit of so great a matter, then surely we pledge a name and glory coeval with the very stars for Your Majesty in the restoration of astronomy, and, so far as in us lies, we will gladly and eagerly procure it. For the rest, [Margin: 140] we most humbly commend Your Sacred Imperial Majesty to the protection of God the Best and Greatest, for the most fortunate governance of the Empire,

and we, the heirs of Brahe, commend ourselves to your Imperial and Parental clientage, freely pledged. At Prague, on the day before the Kalends of August, in the year of the common Christian era 1602.

Of Your Sacred Imperial Majesty

Most obedient clients,

The heirs of Tycho Brahe.

ADMONITIO AD LECTOREM

(A NOTICE TO THE READER)

Our father had intended, kind reader, to set down at the beginning of this volume a few remarks on the dignity and usefulness of astronomy, and also on the plan of the work. But since he left us only imperfect notes, jotted down as memory aids, and since the same subject has long been treated by various authors in various ways, we have scrupled to add even the least thing now that he himself is dead—especially because the conclusion of the book supplies it abundantly. This one thing, at least, we thought worth pressing upon you: since this book grew at different times by different increments, so that its earlier reflections are illustrated by the brilliant discoveries that came later, we advise you to consult the appendix at the very end of the work before you take up the reading of the book itself. We give this warning so that, while reading, you may not suppose we worked carelessly if you fail to weigh accurately—against the later sections, where those matters are treated expressly—the things that were said cursorily and in scattered places by an earlier hand. Farewell, and make good use of these labors.

DIPLOMA CAESAREUM

Tychoni Brahe clementer concessum.

(THE IMPERIAL PRIVILEGE, graciously granted to Tycho Brahe.)

Rudolf the Second [Rudolf II], by the favor of divine clemency Elected Emperor of the Romans, ever Augustus, and King of Germany, Hungary, Bohemia, Dalmatia, Croatia, Slavonia, etc.; Archduke of Austria, Duke of Burgundy, Styria, Carinthia, Carniola, Württemberg, etc.; Count of Tyrol, etc.: to the VALIANT Tycho Brahe [Tycho Brahe], the Dane, Lord of Knudstrup, sincerely beloved by us, our Imperial Grace.

Among the manifold gifts that almighty GOD has bestowed upon the human race, the most illustrious are surely those that consist in the knowledge of the arts and disciplines. And among the arts and disciplines, the ones that hold first place—in

antiquity, in the pleasure worthy of a human being, and not least in usefulness—are those that examine and observe the marvelous harmony of Nature, by which the whole frame and machinery of all created things is fitted together and holds firm; and that measure, test, and weigh the motions of the Heavenly bodies, their momenta, and the source from which the lower bodies derive their strength, vigor, and order. To the cultivation of these arts those heroes of the first age, from the very cradle of the world, judged it their sole task to devote themselves. A thing indeed worthy of itself, and useful and fitting for the preservation of so precious a Treasury of Science, do those men perform who lay out diligent labor and study in arts of this kind. We consider it to belong, as fully as possible, to the office of imperial dignity—to which we have been called by divine favor—to spur on and encourage such men. Therefore, instructed by trustworthy testimony, and indeed by the testimony of those who are able to judge of these arts and sciences, that you have devoted yourself fully and accurately to those studies—

[Margin: 10] [Margin: 7 (marginal apparatus mark)] [Margin: = (marginal apparatus mark)] [Margin: 20 (printed beside "vnde inferioribus corporibus")]

—to cultivate them so perfectly and accurately, and to bring to them so many and so great resources, that in this age your equals are scarcely to be found: For since you, a man of noble birth, did not spare those riches and means by which keen talents (whose work, joined with your own, renders observation more certain and more convenient, especially at this most suitable site chosen for the purpose) are nurtured; nor, finally, the Instruments, made—as you are said to have made them—with singular size and craftsmanship, by which they might be fully equipped; sparing no expense on type, on presses, or on the other aids, so that at home you might have ready everything required for consecrating the monuments of those arts to Posterity; and so devoting all your time, and your very self entirely, to the contemplation of those lofty and heavenly matters, and being so engaged in them that—beyond the exact doctrine of Comets, solidly vindicated from the inveterate errors of older writers (a notable specimen of which you have already published), we may also expect from you new Hypotheses of the celestial motions, which answer exactly to the Observations of every age (something which, as you yourself teach by your most accurate Observations, was achieved neither by the earlier Hypotheses of Ptolemy [Ptolemy] nor by the later Hypotheses of Copernicus [Copernicus])—we were by no means willing to neglect, but resolved, for the sake of the Commonwealth to which these ornaments accrue through you, to take you up to be honored with our Imperial Commendation. And although you are sufficiently encouraged on

your own, you are to be encouraged the more, that you may energetically and eagerly bring to completion what you have so happily begun.

But since we have learned that you have determined to print at home, on your own press, the Works you are elaborating, so that they may come into the light more accurately edited, it is our wish—by this our Diploma and Privilege—that you be protected under a twofold title against the fraud of any Printers whatsoever, who out of greed (as commonly happens) might perhaps wish to print or imitate the same works: both that the copies may come forth purged of the errors that those unskilled and ignorant of the Art easily

commit, and that they may come forth more correct; and also that provision may be made for the indemnity of you, who incur great expenses in this matter. We therefore decree, and by our Imperial Authority establish and forbid, that no Printer, Bookseller, or others who carry on the book trade, dare in any way—by any form or type—to imitate, publish, print, or sell those Books which you, written by you in Mathematics or Philosophy, are about to publish, whether from your own type or from another's, within the bounds of the Holy Roman Empire, our Kingdoms, and our hereditary Dominions, for the next thirty Years reckoned from the first day of publication, without the consent of you or of your heirs. And if anyone be found to have transgressed, violated, or scorned this our Edict, it is our will that he be punished not only by the forfeiture of such books—to be confiscated for you, your heirs, or your assignees, by the aid of the Magistrate, wherever they be found—but also by a fine of twenty Marks of pure gold, of which one half is to be paid to our Treasury's Procurator, the avenger of fraud, and the other half to you, your heirs, or your assignees. We charge all and each of our subjects and the faithful beloved of the Holy Roman Empire, both Ecclesiastical and Political, of whatever state, rank, or order they may be—and especially those who have been set in office, who pronounce judgment or exercise jurisdiction in their own name or in the name of their superiors—that they suffer no one to violate, despise, or neglect this our Privilege with impunity; but, if they find any contumacious, that they take care to punish them with the fine appointed by us, and to restrain them by every means, unless they themselves wish to draw down upon themselves our gravest indignation. All of which we confirm by this Diploma, subscribed by our hand and secured by the impression of our Imperial seal. Given

[Margin: 10] [Margin: 20]

at our royal castle in Prague, on the thirteenth day of the month of June. In the year of the Lord one thousand five hundred and ninety. In the fifteenth year of

our reign over the Romans, the eighteenth of our reign over Hungary, and likewise the fifteenth of our reign over Bohemia.

RUDOLF [Rudolf II]

Jacobus Curtius von Senftenau [Jakob Kurz von Senftenau]

By the personal mandate of His Sacred Imperial Majesty.

Johann Barvitijs, M.P. [in his own hand]

We have obtained similar privileges from several of the most powerful kings, and also from other princes and estates. Since to insert all of these here would be tedious and wearisome to the reader, we have judged it superfluous to do so. There is only one exception: the highly honorable Diploma — granted, together with an accompanying poem, by the illustrious King of Scots, inspector of the optical works and instruments at Uraniborg — which we could not pass over, given how greatly it honors the art.

THE PRIVILEGE OF THE KING OF SCOTS

James VI [James VI of Scotland], by the grace of God King of Scots, to the noble Tycho Brahe, lord of Knudstrup, easily the foremost astronomer of this age.

Those truly distinguished astronomical *Progymnasmata* of yours, which you have worked out over so many sleepless nights with tireless effort — when we learned both from your own letters to us and from our agent Junius [?] that you were about to publish them, and when you earnestly asked that they go forth more adorned and better protected, accompanied by our written endorsement in verse and shielded by our royal privilege, so as to safeguard your interests — we judged that we should not be reluctant to grant either request, since both ought to be conceded without grudging to your singular excellence and to your erudition, which deserves the highest respect.

For these things were not to be learned by us from anyone else's report, nor merely from inspecting your works. Rather, with our own eyes before us and our own ears [Greek: αὐτόπται καὶ αὐτήκοοι (autoptai kai autēkooi, "eyewitnesses and earwitnesses")], we saw and heard them in those halls of yours dedicated to Urania; and from your various, most learned, and most delightful conversations with us we drank deeply. These still so move our mind that it is hard to determine whether we recall them with greater pleasure or greater admiration.

This, indeed, we testify by this diploma — and not unwillingly — to all mortals, present and future: so much so that, if anyone should deliberately wish to visit your Uraniborg (unless he is utterly devoid of taste [Greek: ἄμουσος (amouosos, "without the Muses," uncultivated)]), he will find, on returning home, that his pains have brought a most precious reward.

And so by our royal edict we will and ordain: that no one, of whatever rank, order, or condition he may be, wherever the bounds of our kingdom extend, shall — within the next thirty years from the first edition of each work or volume — by any means whatever (without your mandate or that of your heirs) print these astronomical *Progymnasmata* of yours, or any other works of yours that you shall have had set in type, whether in the same or in a different form of type; nor shall he import into the territories or bounds of our kingdom copies printed by others, nor distribute them in any way whatever, nor offer them for sale. Whoever does otherwise, it is our will that a fine of twenty marks of pure gold be imposed upon him: half of which shall go to our royal treasury as the avenger of the fraud, and the remaining part shall fall to you or your heirs. This is apart from the publication of books printed in imitation of yours: these, wherever in the world you or your heirs or agents shall have found them, you may — with the help of the magistrate administering justice in that place (whom by these presents we strictly charge to assist you and yours by his own authority in recovering your property) — claim for yourselves and reduce into your own possession. In witness of this, we have subscribed this edict with our own hand and confirmed it by the appension of our seal. Given at our royal palace of Holyrood [Sancruciana — Holyroodhouse], on the Kalends of August in the year 1593, the twenty-sixth indeed of our reign.

AN ENCOMIUM OF JAMES VI, KING OF SCOTS, ON THE ASTRONOMICAL WORKS OF THE NOBLE TYCHO BRAHE THE DANE

By twice five ethereal globes, by which the Engine of the World is turned — as high Olympus is encrusted with its lofty vault of fires, and adorned on every side with gleaming lamps — the Planets shine through their glassy houses and vast orbs: so that they double their courses, turning both by force and of their own accord; so that, with a gentle or a grim aspect, they foreshow things long before they come, and what fates the Thunderer sets rolling for kingdoms. If you desire

here on earth to discern these things — what powers, what motions, and what order there are — Tycho's labors lay open the lofty Aether, drawn down to earth. Learn from his law, and you shall see wonders; at home you shall find the World, and the Heavens within a little book.

ANOTHER

How rashly did Phaëthon dare it! How much better does Apollo perform, who, panting in the Aether, guides the fire-breathing Steeds! Yet Tycho surpasses him: he rules all the Stars; Apollo yields to you. You are dear to Urania — her guest, her foster-son, her love.

JAMES THE KING WROTE THIS WITH HIS OWN HAND, AND BY HIS OWN HAND.

BOOK I — ON THE NEW STAR OF THE YEAR 1572

CHAPTER ONE.

On the precise determination of the Sun's course, as established for our own age through more recent observations made under the open sky with various and entirely reliable instruments.

Of all the bodies that the inexhaustible Wisdom of God founded in this vast Theatre of the World, the Sun is the greatest, the most brilliant, and conspicuous for its beauty and majesty; and in its power and effective energy it far surpasses all the rest. By its motion — annual no less than daily — and by the inborn, overpowering brightness of its light, it brings about the distinctions of the seasons, the alternations of years, days and nights, and the changing round of summer and winter, spring and autumn, all by a fixed law. [Margin: 5] [Margin: 10] But it does more than this: by its life-giving warmth and its heavenly power it quickens the whole of Nature and all things that are generated in the lower World — both living creatures and plants, and minerals and metals as well — fostering them and bringing them to their appointed ripeness, so that its force penetrates even into the innermost bowels of the Earth itself. [Margin: 15] At its very nod all the other Planets and the whole Chorus of the heavens direct their own course, honoring it as their renowned King and Leader with a harmony and an attentive observance never once interrupted. [Margin: 20] This Sun, I say, since it excels all the other wondrous lights of the ethereal World in such great prerogative and pre-eminence, and moreover disposes and governs the courses

and the laws of motion of all the rest, so that without a sure and exact knowledge of its own course one would attempt in vain to fix the positions and motions not only of the other six Planets but also of the Fixed Stars — for this reason we rightly judge that, in restoring astronomy, we must begin with this chief and most brilliant luminary, the one most essential of all to the task. [Margin: 25]

Indeed, certain of the ancient Philosophers seem to have said, not without reason, that the Sun was set before the eyes of Men for this very purpose: that they should gaze upon and contemplate it.

[Margin: 5] Now, this exact restoration of the Sun's course as established for our own age — the treatment of which I am about to undertake — may perhaps seem foreign to some, given the design of this Work, in which I proposed to deal with the new and unfamiliar Phenomena of the heavens. Yet without an accurate knowledge of the Sun's motion, even those novel Stars themselves (with which we are to be concerned) cannot be reduced to order. [Margin: 10] For one thing, the determination of their places depends on the Fixed Stars, whose positions cannot — as has been said — be established without reference to the Sun. For another, many other matters arise in the precise assignment of times and in the diligent investigation of the appearances of these phenomena, matters that necessarily require an exact knowledge of the Sun's motion. [Margin: 15] On this account I think I shall not be acting amiss if I set before all the other subjects contained in this Work a careful investigation of the Sun's course as it stands in our own age — [Margin: 20] especially since I judge it not only proper but altogether useful to bring forward (whenever occasion permits) not merely those things which properly belong to the present inquiry into the heavenly Phenomena, but also a number of points that contribute to the better restoration and advancement of the science of Astronomy itself. [Margin: 25] But, so as not to put off the matter itself with lengthy digressions, let me take up the correction of the Sun's course, brought down to our own times from observations under the open sky, which is what I have promised.

This Sun of which we are speaking, that incomparable Astronomer of the former age, NICOLAUS COPERNICUS [Nicolaus Copernicus]

— of Toruń [Toronensis] — on account of its supreme dignity, and led also by certain other considerations, did not hesitate to place altogether motionless and at rest in the center of the universe; so that not only do all the remaining Planets revolve around it in the very midst of their own revolutions, but the Earth itself, [Margin: 5] together with the Moon, its near neighbor, is carried yearly around the same Sun, with a sufficiently capacious space left between the Orb of Mars

and that of Venus. We read that certain of the ancients held this same opinion too — among the first of them Aristarchus of Samos [Aristarchus Samius]. [Margin: 10] But we, together with the most ancient Astronomers and with the commonly received opinion of the Philosophers, declare without any hesitation that the Earth occupies the center of the universe, and that the Sun is carried about it in an annual motion. As for the reasons why this arrangement of the apparent circuits of the heavenly bodies, however ingeniously and elegantly devised by that great COPERNICUS [Copernicus], does not in reality correspond to the truth, we shall show sufficiently elsewhere.

But since the SUN itself, encircling the Earth (which is set in the middle of the universe) year by year, is not — to all appearance — carried along at a uniform pace ever like itself, [Margin: 18] but is found by careful attention with Instruments to advance more slowly in the summer part of the Ecliptic and more swiftly in the winter part — so much so that from the vernal Equinox to the autumnal it spends about $8\frac{3}{4}$ days more over the whole Northern semicircle than over the Southern; [Margin: 24] and since it is laid down as an Axiom long ago received by all Astronomers that all celestial motions are in themselves regular and uniform, and are carried in a circle by a constant law — it will follow that the Sun, in order to be carried along by a simple and regular course, does not everywhere look toward the Earth in its own path

— that is, toward the place of the center, but keeps a different point, outside the center of this its own circuit, as the middle-point. Hence it comes about — what has now for many ages past been established — that the Sun is carried in an Orb that is Eccentric with respect to the Earth, or (what amounts to the same thing) in a concentric epicycle.

[Margin: 6] But for the sake of convenience, preferring here the Eccentric, we shall investigate, from observations made in the Sun's course that are themselves certain and definite, the point at which the Sun comes to be most remote from the Earth (which they call the Apogee or Auge) and the distance of the center of that same Orb from the center of the Earth, which is termed the Eccentricity; for this above all must be ascertained first.

[Margin: 11] That the Sun is in truth carried in some Orb eccentric to the Earth, so that it is rendered now nearer, now more remote from us, is something proved well enough not only by the slowness of its motion in summer and its swiftness in winter, of which we have said something, but also by the fact that its visible diameter, under attentive observation, appears somewhat larger near Perigee than near the Apogee of the same Orb — which convinces us that the matter

cannot stand otherwise. The Eclipses too bear undoubted testimony to this assertion. Let the makers of Homocentric Orbs, then — those too violent in themselves — be gone with their fruitless effort.

[Margin: 21] Now, so that the inquiry into this Apogee and the Eccentricity may be duly carried out, it will first of all be necessary to have settled the Sun's simple daily motion, which, however, is not required in this place with precise exactness. We shall therefore assume the magnitude of the Tropical year to be 365 days 5 hours 49 minutes [365. H 5. M. 49], as it is found to be most nearly by comparing the long-continued observations of skilled practitioners. For on account of some small inequality — to which it is held to be subject from one set of Observations to another, and above all from that great COPERNICUS [Copernicus] — so that by a few small scruples

sometimes turns out otherwise with the assistants, something is detracted from our purpose. For whatever error spreads insensibly through the whole circle will, when broken up into its smaller parts, be of no consequence at all.

Now, if by means of this presupposed length of the year we divide the whole circle, which is 360 degrees, there will emerge the simple daily motion of the Sun: $0^{\circ} 59' 8'' 19''' 43'''' \frac{1}{2}$, which is sufficient for our purpose. We shall make use of this very figure shortly in investigating and demonstrating the solar Apogee and the Eccentricity appropriate to our own times.

Now I shall set out the things drawn from the observations themselves which are needed for this matter. First of all, then, I shall lay before the reader's eyes the entries of the Sun into the two equinoctial points, such as I have investigated by careful observation in the heavens within the five years just past.

The Sun's entries into both equinoctial points, traced out from our exact Observations.

ANNO CHRISTI LABENTE [Year of Christ, current]	VERNALE — MARTII — DIE [Vernal, of March, day]	VERNAL E — HOR. [hour]	VERNALE — MINVT. [minute]	AVTVMN ALE — SEPTEMB RIS — DIE [Autumn al, of Septembe r, day]	AVTVMN ALE — HOR. [hour]	AVTVMN ALE — MINVT. [minute]
1584	9	21	30	12	16	0
1585	10	3	19	12	21	49
1586	10	9	8	13	3	38
1587	10	14	56	13	9	26
1588	9	20	45	12	15	15

The heading band of the table reads AEQVINOCTIVM [Equinox], spanning the two equinox blocks: VERNALE [Vernal] and AVTVMNALE [Autumnal].

The hours and minutes are counted from the noon of the assigned day, and that for the Longitude of 36° 45', which is the one at the place of our Observation, the nearest one.

These determinations of the equinoctial times I derived from the heavens, using five or six Instruments built on different principles. They were elaborated so precisely — in their very size, in the metallic solidity of their material, in their graduation, and in the exact arrangement of their sights — that they left us in no doubt whatever about the Sun's Altitudes down to a fraction of a Scruple: in some cases a third, in others a fourth, and in a few even a sixth part of a Scruple.

Without that precision this delicate undertaking is attempted in vain. For a single minute of variation in Altitude — and on that account a single minute in the Sun's Declination, right at the equinoxes themselves, where the daily change of Declination is greatest — shifts the Sun's Longitude by 2 ½ scruples, and these, over the course of time, very nearly make up a whole hour. Hence it is clear how vainly those try to enter the inner sanctuary of Astronomy who are not equipped with Instruments wrought with the utmost care and precision. And here, surely, lies no small part of the reason why this Science has not yet come down to us complete in all its parts from the earlier Mathematicians, but has crept in piecemeal — so much so that they could not even render the motion of the Sun, on which all the rest depend, precisely known.

Together with the Altitudes themselves, I also took account of the Sun's Parallax [parallax Solis], which our predecessors seem to have passed over too carelessly in so delicate an inquiry. Indeed, I judged that even that small Refraction which here affects the Sun — even near the Equinoxes, at an elevation of nearly 34 degrees — should not be left out of account. Furthermore, the Altitude of the Pole, which in a practical matter of this kind must be ascertained with the greatest exactness, must be derived from the circumpolar Stars, and especially from the Pole Star [Stella Polaris] itself, which describes the smallest circle and, in our Climate, is not subject to refraction...

I investigated this many times with careful attention. For the reasoning that is here adopted from the Sun, in both Solstices, is not free from appreciable error — especially because, near the winter Solstice [Brumam], in the Sun's lower position, an evident deviation arises from its insinuating itself, through refraction, away from its true Altitude. Granted that Parallax is not neglected — which few, or rather none, so far as I know, have attended to before — yet this matter has cost us no small effort. For while I was investigating the precise Altitude of the Pole here with one well-wrought instrument and then another, and that by both methods — both through the Sun's Elevation at the two Solstices, and also through the elevation of the Pole Star, both its greatest and its least — I found that the result by no means agreed with itself, the discrepancy being quite perceptible, since it even exceeded four prime scruples by a little. From this I was led into doubt about the exact construction of the Instruments, and I did not cease to have various Instruments made, one after another, of different shape and size, until at last I had at hand at least ten, built to the most exact perfection, with which the Altitudes of the Sun and the Stars could be very scrupulously examined — Instruments of inestimable Labor, Diligence, and Expense. And when, with all of them alike, I had found the same thing — namely, that the Altitude of the Pole derived from the circumpolar Stars exceeded the one found through the Sun at either Solstice by more than four scruples (as I said) — I weighed the cause of this discrepancy diligently and on every side, not without astonishment (since I was already sufficiently certain it could not arise from an error of Observation, on account of the agreement of so many great Instruments). And at last it occurred to me...

at last, that it came about on account of the refraction which the Sun produces near the winter Solstice [Solstitium hybernum], when it is barely elevated 11 degrees above us. For its position, in so low a situation toward the Horizon, appears to us by refraction elevated higher than it actually is in the Sky itself — the principles of Optical doctrine concurring, on this point beyond doubt.

Nevertheless, I had suspected that so great a refraction in the Sun, one that would introduce so evident a discrepancy, could scarcely occur. For the Sun in its winter position must, through refraction, be seen at least 9 scruples higher than it should be.

For this reason I also had another Instrument made, an Armillary one, whose Diameter was ten feet, so arranged that its axis corresponded exactly to the axis of the World [axis Mundi]; and by means of a revolving Armilla it would yield precisely the Declination of the Sun and the Stars, even outside the Meridian, in whatever position they might be. By the help of this I was quite convinced that the Sun does indeed admit so great a refraction in a low position. For near the summer Solstice [Solstitium aestivum], when the Sun is at its greatest Altitude at the Meridian — nearly $57\frac{1}{2}$ degrees — it suffers no refraction at all, or one altogether imperceptible. By tracking its Declination through that same Armilla, both at times before noon and after noon, with the Armilla revolved together with the Sun from rising all the way to setting, and examining it morning and evening at an Altitude of 11 degrees (about what it is here at midday near the winter Solstice [Brumam]), I found a greater difference than the nine scruples nearly required: by very nearly the same measure as in the winter Solstice, the Sun appears to us higher than it actually is. And since I have applied diligent experience to this matter for several years in succession, with regard to the Sun's refractions in its lower position, all the blame for this (of which I spoke) discrepancy...

about the pole's altitude, I no longer hesitated to reject it — especially since near the horizon itself we observed, through the same Armillary instrument, a refraction that came close to amounting to half a degree. From this it also comes about that the Sun appears to rise a little earlier each day, and to set a little later, than its true ascent and descent would require. The difference is quite perceptible, since it reaches four or five scruples [minutes], and at times even exceeds that; for it does not always remain constant and equal to itself, on account of the varying density of the vapors near the horizon — even under a perfectly clear sky.

From all this it further follows that the Sun's maximum declination, even when sought out with the greatest care from its meridian altitude at both solstices, cannot in any way be established correctly. It necessarily comes out smaller than the true value, because of that perceptible entanglement of refraction near the winter solstice [Brumale Solstitium] which I just mentioned. For this reason the truest divergence of the ecliptic from the equator — the value they call the

maximum declination — becomes evident only when one starts from an exactly determined pole-altitude and from the precisely known elevation of the Sun at the summer solstice, when it is at its highest, with the Sun's parallax applied; for there no obstacle of refraction creeps in. By this very method, in fact, over a number of years now and with great care, using several instruments, we have found that value to be $23^{\circ} 31\frac{1}{2}'$. This same value we have unhesitatingly relied on in correcting the solar motion, which is our present concern. Nor are we held back by the fact that in an earlier age that value was found by the most excellent mathematicians — Regiomontanus, Werner [Johann Werner], and Copernicus himself, along with certain others — to be very nearly $23^{\circ} 28'$, with almost all of them agreeing on roughly the same figure. For however many of them held that erroneous value [for the maximum decli-

nation], they did so because, in determining both the Sun's maximum and minimum altitude as it enters either solstice, they did not guard carefully enough against the impediments of refraction — indeed it is likely that they took no account at all of parallax. Thus we too, from the Sun's meridian altitude at both solstices, found its maximum declination in our own age to come out as $23^{\circ} 28'$ [Margin: 6] — the very same as our predecessors discovered, that is, if the Sun's parallax is neglected; but if that parallax is applied at both points, the declination turns out smaller still by one scruple. In this too there is no great disagreement with the value that the man worthy of all praise, Bernhard Walther [Bernhard Walther], citizen of Nuremberg and pupil of Regiomontanus, left behind from observations of the Sun's solstitial altitude made over a number of years in his lifetime.

[Margin: 14] I dwell on these matters at such length so that it may be established that our observations of the solar course harbor no defect whatever that could secretly fall into them, and that we have brought to bear, circumspectly and without any shortcoming, everything necessary for this investigation. Thus, as for the equinoctial entries indicated above, let there be no doubt that they hold accurately enough — once they have been compared with one another carefully, and also examined each on its own, against the observations of the five preceding years. But if the solstices were as open to certain observation, the investigation of the apogee and the eccentricity would certainly be no difficult matter — the very point on which there is good reason to suspect that Ptolemy and his predecessors, and Albategnius [al-Battānī] too [Margin: 24], fell short: namely, that they relied in vain on the solstitial entries, which are least of all exactly determinable. I did indeed devise a peculiar method of my own by which the solstices, the winter one especially, might be tracked down; but be-

cause more things are required here than at the equinoctial points, this line of reasoning does not seem everywhere safe enough. I shall set it out elsewhere, and if everything is carried through with the utmost care, I shall show that it agrees with the method I am now pursuing.

Therefore, by way of other places lying between the solstices and the equinoxes — such as the middle parts of Taurus [♉] and Scorpio [♏] — compared against the equinoctial points, we shall undertake the investigation of the apogee and the eccentricity.

There follows the procedure for determining the Sun's apogee and eccentricity.

[Margin: vide p. 810 l. penult. (handwritten)]

From the solar entries into both equinoctial points noted above, it is gathered that the Sun, traveling from the vernal equinox all the way to the autumnal one, completes — in this present age — 186 days, 18½ hours. From the vernal point onward, as far as the middle of Taurus [♉], or rather to its completed 15th degree, I found that 46 days 2 hours 55 minutes elapse. Likewise, from the 15th degree, or midpoint, of Scorpio [♏] all the way to the autumnal equinox, I find 46 days 9 hours 40 minutes elapse — just as we have determined over several successive years, with no less diligence and circumspection than in marking the equinoxes themselves. From these data, then, we shall investigate an exact measurement of the solar apogee and eccentricity in the manner that follows.

First, in the figure that follows, let there be that orbit which is eccentric to the Earth, the orbit which the Sun marks out by its yearly journey with uniform motion: T H L O, whose center is Z. The Earth, or the center of the universe, lies near E; and let the line H Z E O be drawn through these two points. The Sun's apogee, then, or its greatest distance from the Earth, will be near H, and its nearest point — the perigee — at O. The line

Z E, however, measures the eccentricity itself — that is, the distance of the center of the solar orbit from the center of the universe — and these are the two things we intend to investigate. For this to be done properly, the following points must first be set in order.

Diagram. A large circle representing the Sun's eccentric orbit. A vertical diameter runs from H at the top to O at the bottom; a horizontal diameter runs from the left point (marked with the Libra sign ♎ and the letter L) to the right point (marked with the Aries sign ♈ and the letter T). The two diameters cross near the

center, where a small cluster of points Z, E, and U is marked, with a small dotted right-angle symbol. Additional straight lines (chords and radii) connect the labeled points: from H and O through the center, from the upper-right point Q to the center region and toward P, and from R (on the left horizontal radius) down to P (at the lower left). The construction shows the eccentric circle, its two centers, and the lines used in the apogee/eccentricity proof.

- H (top): apogee point of the Sun's orbit
- O (bottom): perigee point
- L, ♎ (left end of horizontal diameter): the Libra point (autumnal equinox)
- T, ♈ (right end of horizontal diameter): the Aries point (vernal equinox)
- Z (center cluster): center of the eccentric solar orbit
- E (center cluster): the Earth, or center of the universe
- U (center cluster): point on the central construction
- Q (upper right): the Sun's entry into the middle of a sign
- R (on left horizontal radius): point on the line R P
- P (lower left): point connected by the lines from R, from Q through E, and to the circle

is what we intend, and for it to be carried out properly, the following must first be arranged.

Let the line L T be drawn through E, the center of the Earth, cutting the former line H O at right angles. It is then clear that the equinoxes occur for us at L and T; and since the arc L H T is greater than the arc T O L, the Sun therefore appears to linger longer in the northern semicircle, toward H where the apogee is, than in the other, southern one, around O where the perigee is. Let there be, moreover, in this same figure, Q, the Sun's entry into the middle of the twelfth-part [Dodecatemoron] of Taurus [♉]; and from that place let a line be drawn through E to P, which shall be Q E P; and let it be connected with

the point P, where the spring equinox falls at ♈ [Aries], through the line PT; and besides, from the same point P let a perpendicular be drawn toward LT, which is PR. Furthermore, from Z, the center of the eccentric, let a line ZQ be drawn to the midpoint of ♉ [Taurus]; and finally, from Z to E let the perpendicular ZV be drawn upon EQ. In this configuration, then, the angle HEQ will give the distance of the apogee from the midpoint of the sign ♉ [Taurus], and the line ZE itself will give the eccentricity — the two quantities which we intend to determine from the given equal motions of the intervals assumed along the Sun's path, and that by the following method of reasoning.

First: since the time from the entry into Υ [Aries] up to the midpoint of ϑ [Taurus] is known to be 46 days, 2 hours, 1 minute [Margin: 55], the simple motion of the Sun corresponding to it will also be established, computed according to the proportion of the equal diurnal travel assumed above: $45^{\circ} 27' 34''$ [P. 45. l. 27. ll. 34]. This measures the arc $\triangle Q$ [recte: TQ — i.e. the arc from Υ to Q]. To the other arc — namely THL from Υ to $\triangle$ [Libra], that is, the time previously indicated of 186 days, $18\frac{1}{2}$ hours — there correspond, in the same way, $184^{\circ} 5' 24''$ [P. 184. l. 5. ll. 24]; and the complement of this makes up the remaining arc LOT, $175^{\circ} 54' 36''$ [P. 175. l. 54. ll. 36]. There is given, besides, the angle TEQ, 45° [P. 45], from the apparent motion of the Sun from the beginning of Υ [Aries] to the middle of ϑ [Taurus]. Moreover, half of the arc QT, known previously, makes the angle QPT — that is, EPT — since this angle stands at the circumference of the circle and is double that which stands at the center (as is established from the *Elements* of geometry). It therefore comes out to $22^{\circ} 43' 47''$ [P. 22. l. 43. ll. 47]. For this reason the angle PTL also becomes known, since PET is first established as the complement of the angle TEQ to a semicircle, $135^{\circ} 0'$ [P. 135. l. 0]; while the angle LTP, $22^{\circ} 16' 13''$ [P. 22. l. 16. ll. 13], follows from the complement of the two angles QPT and PVT to a semicircle — because in the triangle PET two of the angles, at E and at P, are known, and if they are subtracted from two right angles they leave the third, at T, known, as the *Elements* of Euclid teach;

or, to proceed more simply: the angle PTL is the complement of the angle QPT to the magnitude of the angle TEQ. The arc PL, in turn, is double this angle: $44^{\circ} 32' 26''$ [P. 44. l. 32. ll. 26]. Next, if we subtract the arc LP from the arc LOT, the arc QPOT will remain, $131^{\circ} 22' 10''$ [P. 131. l. 22. ll. 10], whose chord is the line PT, 18 22 58 68 [P. T 18. 22 58 68]. There is given besides the arc POQ, by the addition of QT — known previously — to the arc POT just found, $176^{\circ} 49' 44''$ [P. 176. l. 49. ll. 44], whose chord PQ is 1999 23 42. Further, the angle PER, opposite the angle QET, will not be hidden: it is in fact $45^{\circ} 0'$ [part. 45. minut. 0], equal to the other, and its sine is 707 1068. Now in the triangle PER the proportion of PE to PR is as the sine of the angle PER to the whole sine, because the angle at R is a right angle by construction. There is, besides, the sine of the angle LTP, 37 897 61. The proportion of TP to PR, in turn, is as the whole sine to the sine of this angle LTP. Therefore, for the magnitude in which TP was previously given as 182 258 68, the chord PR will be 69 07 168; and since the proportion of PE to PR (as I said) is as the sine of the angle PER to the whole sine, while the sine of the angle PER is 707 1068, then for the magnitude in which PR is 69 071 68, PE will be 97 68 210. Let PE now be subtracted from PQ, known above: there will remain EQ, 102 24 132. Afterward let QP be bisected at V, and on that account QV will be 999 6171, namely half of PQ itself. Finally, in the triangle ZEV, right-angled by the drawing

of ZV — for if the line is imagined extended from Z to P, it will be equal to ZQ, since it issues from the center of the same circle, and since PQ is equally divided at V, it meets PQ at right angles — we shall measure the line ZV thus. The complement of the arc POQ to a semicircle is $3^{\circ} 10' 16''$ [P. 3. l. 10. ll. 16], whose sine is 5 5318 2, and half of this sine equals the arc [recte: chord] ZV, 27 6591; while EV is obtained by the subtraction of QV from QE, 22 79 61. For this reason, in the said

rectilinear triangle, from the two given sides about the right angle ZV and EV, the angle ZEV becomes known by the table of useful numbers [Canon facundus], $50^{\circ} 30'$ [P. 50. l. 30], emerging namely from the useful number 12 13 41 38. This angle measures the distance of the apogee H from the point Q, the midpoint of γ [Taurus]. The apogee of the Sun therefore falls — by adding this angle of $50^{\circ} 30'$ to 15° of γ [Taurus] — at $5^{\circ} 30'$ of $\mathfrak{S}$ [Cancer, $\mathfrak{S}$] [in P. 5. l. 30 $\mathfrak{S}$]. There is known besides the third side ZE, 35 84 16, in the magnitude in which EV was 227 961 and ZV was 27 6591; or, in the magnitude in which the whole sine is 10000000, which corresponds to the semidiameter of the eccentric HZ; and consequently, in the magnitude in which the semidiameter of the eccentric is 60, the eccentricity will be $2^{\circ} 9' 2''$ [P. 2. l. 9. ll. 2]. The apogee lies near the $5\frac{1}{2}^{\circ}$ of $\mathfrak{S}$ [Cancer] found before [part. $5\frac{1}{2}$ $\mathfrak{S}$] — the two things which we proposed to determine by this procedure.

By the same method we shall investigate the same things for the middle of the sign ϱ [Leo, ϱ], where the figure must be laid out a little differently, and that in the way which will presently become clear.

The interval of time from the Sun's apparent transit through 15° of ϱ [Leo] up to the point of the autumn equinox is 46 days, 9 hours, 40 minutes (as we indicated above), to which there correspond, of the mean motion of the Sun according to the reckoning stated before, $45^{\circ} 44' 13''$ [P. 45. l. 44. ll. 13]; these determine the arc QL. The mean motion of the Sun from γ [Aries] into ϱ [Libra] is, as before, $184^{\circ} 5' 24''$ [P. 184. l. 5. ll. 24], representing the arc THL, whose complement to the whole circle gives back the remaining arc LOPT, known to be $175^{\circ} 54' 36''$ [P. 175. l. 54. ll. 36]. The angle LEQ, moreover, is established from the true and apparent motion of the Sun from the mean position of ϱ [Leo] to the beginning of ϱ [Libra], which is exactly 45° [45 part. precise]. The angle QPL is half the arc QL, and therefore $22^{\circ} 52' 6''$ [P. 22. l. 52. ll. 6]; while the angle LEP is given from the complement of the angle LEQ to a semicircle, $135^{\circ} 0'$ [P. 135. l. 0]. Then the angle

ELP is the complement of the two conjoined angles QPL and LEP to a semicircle, or it is the difference of the angle QPL from LEP, $22^{\circ} 7' 54''$ [P. 22. l. 7. ll. 54]. The arc TP, besides, is double

Diagram. A circle representing the Sun's eccentric orbit, with a cross of two principal diameters and several chords drawn to the eccentric's center and to the Earth. The apogee H stands at the top and the perigee O at the bottom on the vertical diameter; the horizontal diameter runs from $\varnothing$ [Libra] at the left to Υ [Aries, marked with the ram symbol] at the right. Near the center sit the two close-set points Z (center of the eccentric) and E (the Earth / center of the universe), joined by a short dotted perpendicular (the eccentricity ZE) with a small right-angle mark. The body-point Q [Sun, marked with the $\odot/\text{☿}$ -like sign for the planetary place] lies on the upper-left of the circumference, with lines drawn from it down through the center region to the Earth E. The point P lies on the lower-right of the circumference, and R lies on the horizontal diameter between the center and Υ on the right. Lines connect Q, P, E, Z, R, and the diameter endpoints, forming the triangles (PER, PET, PLR, ZEV) used in the derivation.

- H (top, on vertical diameter): apogee [auge]
- O (bottom, on vertical diameter): perigee
- $\varnothing$ L (left end of horizontal diameter): Libra, point L
- Υ T (right end of horizontal diameter): Aries / the ram (spring equinox point), point T
- Z (just above center): center of the eccentric
- E (just below Z, at center): Earth / center of the universe
- Q (upper-left of circumference): the Sun's position [marked with planetary-place sign]
- P (lower-right of circumference): point P (computed body position)
- R (on horizontal diameter, right of center): foot of the perpendicular PR
- T (right end of horizontal diameter, with Υ): point T (= Υ endpoint, spring equinox)

the angle ELP, so that it is $44^\circ 15' 48''$ [P. 44. l. 15. ll. 48]. Afterward the arc LOP also becomes known, from that difference which lies between TP and LOPT, $131^\circ 38' 48''$ [P. 131. l. 38. ll. 48], whose chord PL is 18 24 5736. There is established likewise the arc QLOP, from the conjoined arcs QL and LOP, $177^\circ 23' 1''$ [P. 177. l. 23. ll. 1], whose chord, 1999 47 84, is represented by the line QP. The angle PET, moreover, is equal to the angle QEL — that is, set opposite to it — namely $45^\circ 0'$ [P. 45. l. 0]. And since in the triangle PLR the proportion of the side PL to PR is as the whole sine to the sine of the angle RLP, and the sine of this angle is 3767364, there will result

PR is 6,873,833 of the units in which PL is 18,245,736. From here, in triangle PER, the ratio of side PR to side PE is also established — as if it were the sine of angle REP, which is 7,071,068 against the whole sine. Hence PE comes out as 9,721,068 of the units in which PR is 6,873,833. Now subtract from this PE the value of FQ, already known earlier, and there will remain QE 10,273,716. Halving QP, it will be clear that QV is 9,997,392; and from this EV too will not be unknown, once QV is subtracted from QE 276,324.

Moreover, the complement of arc QOP to the semicircle is P.2.1.36.11.59 [2°36'59"]; its sine is 456,488, and half of this equals ZV 228,244. Therefore in triangle ZEV, from the two given sides about the right angle — namely ZV, which has just been shown, and EV, found earlier to be 276,324 — there results, by the method of plane triangles, the number 8,260,374. This, by the *Canon facundus*, yields angle ZEV as 39°.1.33 [39°1'33"]. Now this angle ZEV is the same as angle HEQ, which measures the distance of the Sun from the apogee when it passes through the midpoint of Leo [♌]. If, then, this angle is counted backward from 15° Leo [♌], the Sun's apogee falls at P.5.1.27 [5°27'] of Cancer [♋].

Next, since the third side of the same triangle ZVE can also be established from those same given quantities, that side ZE will be 358,388, of the units in which ZV is 228,244 or EV is 276,324. Now these two have a relation to the whole sine, which corresponds to the radius of the circle; therefore, of the units in which the semidiameter ZH of the eccentric is 10,000,000, ZE — the eccentricity of the Sun — will be 358,388. Or, what amounts to the same thing, of the units in which the semidiameter of the eccentric is taken as P.60.1.0, the eccentricity itself comes out as P.2.1.9.11.1 [2°9'1"], with the apogee (as I said) reset earlier at P.5.1.27 of Cancer [♋].

These two results, investigated in this way from the equinoctial places and from the passage through the midpoint of Leo [♌], as we set out to do, agree well enough with those obtained through the midpoint of Taurus [♉],

—established earlier in the same way, with a discrepancy in the apogee's place amounting to at most 3 scruples [scrup]: a difference of no consequence whatever, and in this practical matter imperceptible. The eccentricity, too, remains almost the same as before, the discrepancy from the foregoing arising only in a single second.

[Margin: 6] And so, for the year 1588, taking the place of the solar apogee at the midpoint of 6° Cancer [♋] and the eccentricity of the Sun as 3,584 of the units in which the semidiameter of the eccentric is 100,000 — or P.2.1.9 [2°9'] very nearly,

of the units in which the same is taken as P.60.1.0 — the matter itself will testify, beyond all suspicion of error, that we have rightly attained our proposed aim. What we resolved to investigate we have now also shown to be demonstrated.

I have, in addition, compared the Sun's entries into 10° of Cancer [♋], Taurus [♉], and Leo [♌], gathered from the heavens by us in the preceding years with no less diligence than the rest, against the equinoctial limits. Everywhere I have found exactly the same eccentricity, and likewise around the apogee, with a difference of no consequence whatever intervening — indeed imperceptible — so that no further doubt remains [Margin: 19] that the limits of the solar apogee and eccentricity have been duly and exactly fixed by us, accurate to the proposed time.

ADMONITIO AVTHORIS. [The Author's Admonition]

In this way, by means of accurate observations over a five-year span in the Sun's course, we have restored its apogee and eccentricity to their proper position and measure. But because, from the observations I obtained in the year 1583, I found these values to differ by a very small amount — observations from which the figures previously published in our Ephemerides of the Sun [☉] and communicated to certain mathematician friends of ours were drawn — I am willing to record here too the foundations and superstructure of that earlier determination, so that it may be plain from what source that minute difference arose. Briefly, then, I shall set out everything that is required for this.

For the year 1583, from the observations I then had of the Sun, I established the interval from Aries [♈] to Libra [♎] as 186 days, 18 hours, 41 minutes — a little greater than the value just assumed, exceeding it by only about 2 minutes. From the beginning of Aries [♈] to the middle parts of Taurus [♉]: 46 days, 2 hours, 48 minutes; and from 10° of Leo [♌] to the beginning of Libra [♎]: 51 days, 15 hours, 10 minutes. From these I deduced the apogee and eccentricity for that time as follows.

First, taking account of the midpoint of Taurus [♉] as compared with the equinoxes, and applying this construction, proceeding as in what went before, there results arc TQ, P.45.1.27.11.16 [45°27'16"]; arc THL, P.184.1.5.11.50 [184°5'50"]; arc LOT, P.175.1.54.11.10 [175°54'10"]. Angle TEQ is P.45.1.0 [45°0']; angle QPT, P.22.1.43.11.38 [22°43'38"]; angle PTR, P.22.1.16.11.22 [22°16'22"]. Arc PL, P.44.1.32.11.44 [44°32'44"]; arc POT, P.131.1.21.11.26 [131°21'26"], whose chord PT is 18,224,992; arc POTQ, P.176.1.48.11.42 [176°48'42"]. The chord PQ is 19,992,258. The ratio of PE to PR is as 10,000,000 to 7,071,068; the ratio of TP to PR is as 10,000,000 to 3,790,165

— for so great is the sine of angle PTL. Therefore, of the units in which TP is 18,224,992, PR will be 6,907,573, and consequently PE, of like units, 9,768,783.

Hence the remaining EQ is 10,223,475; from which, subtracting QV 9,996,129 — namely half of QP itself — there remains EV 227,346. The complement of arc POTQ to the semicircle is P.3.1.11.11.18 [3°11'18"]; its sine is 556,182, and half of this is 278,091, which equals ZV. Therefore, from the two given sides EV and ZV about the right angle, there results angle ZEV, P.50.1.44 [50°44'], which measures the distance from the apogee to the middle part of Taurus [♉]. The side ZE comes out as 359,194, of the units in which the whole sine is 10,000,000. The eccentricity comes out as P.2.1.9.11.18 [2°9'18"], of the units in which the semidiameter of the eccentric is 60, and the apogee falls at P.5.1.44 of Cancer [♋].

Diagram. An eccentric circle for the determination of the solar apogee and eccentricity, corresponding to the Taurus-midpoint computation. The circle is drawn with a vertical diameter from H (top) to O (bottom) and a horizontal diameter terminating in the zodiac signs Libra (♎, marked L at left) and Aries (♈, marked at right, with T). The center Z and the Earth's position E lie near the middle, slightly offset, with V between them. Point R lies on the horizontal radius left of center; Q lies in the upper right quadrant; P lies in the lower left quadrant. Straight lines connect the points (P–Q, P–T, the radii and chords used in the trigonometric construction).

- H (top of vertical diameter): apex / upper apse
- O (bottom of vertical diameter): lower apse
- L / ♎ (left end of horizontal diameter): Libra
- ♈ / T (right end of horizontal diameter): Aries
- Z (near center): center of the eccentric
- E (near center, below Z): the Earth / center of the universe
- V (between Z and E): intersection point
- R (on horizontal radius, left of center): construction point
- Q (upper right quadrant): construction point
- P (lower left quadrant): construction point

In the other position too — namely at 10° of Leo [♌] — considering this other figure in the same manner, everything stands thus: QI, P.50.1.53.11.28 [50°53'28"]; QPL, P.25.1.26.11.44 [25°26'44"]; PT, P.49.1.6.11.32 [49°6'32"]; LOPT, P.175.1.54.11.10 [175°54'10"]; LOP, P.136.1.47.11.38 [136°47'38"]. LP is 17,882,600. Arc POLQ is P.177.1.41.11.6 [177°41'6"]; PQ is 19,995,920; PV is 9,997,960; RP is 7,431,252; PE is 9,700,810; EV is 297,150. The complement of arc POLQ to the semicircle is

P.2.1.18.11.54 [2°18'54"]; its sine is 403,935, half of which is ZV 201,967. And angle ZEV will be P.34.1.12 [34°12']; the side ZE, 359,321. The apogee accordingly comes out at P.5.1.48 of Cancer [♋], differing from the earlier value by at most 4 imperceptible scruples; and the eccentricity is P.2.1.9.11.21 [2°9'21"] nearly — this too agreeing well enough with the earlier result.

Diagram. A second eccentric circle, of the same construction as the upper one, for the Leo computation (10° of Leo [♌]). The vertical diameter again runs from H (top) to O (bottom); the horizontal diameter runs from L / Libra (♎, at left) to ♈ / Aries (at right). The center Z and the Earth E lie near the middle with V between them; here R lies on the horizontal radius to the right of center, Q lies in the upper left quadrant, and P lies in the lower right quadrant — the configuration mirrored relative to the upper figure. Chords and radii (P–Q, P–T, etc.) are drawn for the trigonometric derivation.

- H (top of vertical diameter): apex / upper apse
- O (bottom of vertical diameter): lower apse
- L / ♎ (left end of horizontal diameter): Libra
- ♈ (right end of horizontal diameter): Aries
- Z (near center): center of the eccentric
- E (near center, below Z): the Earth / center of the universe
- V (between Z and E): intersection point
- R (on horizontal radius, right of center): construction point
- Q (upper left quadrant): construction point
- P (lower right quadrant): construction point

Therefore, from these observations, I at that time presupposed the Sun's apogee to lie near the 5¾ part of Cancer [♋], and its eccentricity to be 2°9½, of the units

—in which the semidiameter of the eccentric is 60. With these I made use of the Sun's course in verifying, and I built up Tables of Prosthaphaereses upon such foundations, together with a correction of the simple motions; from which I also derived Ephemerides for several of the years then nearly running, which (as I said) I granted to friends in various places who requested them of me.

But because in those same Ephemerides a discrepancy of several seconds emerges from the motion deduced by this renewed calculation, I therefore wished to give notice of this here, so that it might be known that one ought rather to abide by this later correction — even though the difference is extremely slight, never amounting to a whole minute, in whatever place of the Sun's course these

calculations may be sought. [Margin: 11] And indeed, to fix the Sun's course so scrupulously, down to the very seconds, seems unusual, since it cannot be perceived by any instrument, and the bare evidence of the eyes refuses so subtle a discernment. For this reason the second scruples [the seconds] are not so much assigned in the numbering of the Sun's motion because they can be established with certainty, without any deviation, as rather that, by neglecting them, we may not become entangled in a defect of some whole minute or of half of one.

[Margin: 17] As to the fact that I found a somewhat greater eccentricity, and the apogee also advanced somewhat further, from the observations of the year 1583 — this happened chiefly because I applied the equation of time [aequatio temporis] in the entries of the assumed places, which was not necessary, and because I did not limit the altitude observed near the equinoxes for the small refraction that there too creeps in. At that time, moreover, I made use of an elevation of the pole [Margin: 23] for this place of P.55.M.54½ [55°54'30"], since in some preceding years I had found it to be P.55.M.54⅔ [55°54'40"], those ten seconds being neglected; but here I applied a more limited, and in its few seconds more refined and exact, value for the pole's altitude. So too I was at that time content with a greatest declination of P.23.M.31½ [23°31'30"], which is now taken more exactly, greater by half a scruple. And so, from these concurrent causes — not in themselves very evident — that very slight difference in the apogee and eccentricity for the year 1583 quietly insinuated itself, which nevertheless could alter the Sun's motion only imperceptibly.

And I judged that this should be pointed out in this place so that those who had previously obtained our Ephemerides — calculated from the determination of the apogee and eccentricity found in the year 1583 — might also know the reasons why this latest restitution does not in the seconds of the Sun's motion present everywhere a result similar to the earlier one, and so that it might be established from what source it comes that in the following Book, in the Hypothesis of the Comet, we have assumed the eccentricity itself, to be set out in the Eighth Chapter, as part 360, of the units in which the semidiameter of the eccentric is 10,000 — since that number comes as close as possible to the determination just indicated, just as the apogee too is there found to be advanced a little further, a value which is likewise founded as closely as possible on these and other observations, though with a slight anticipation deliberately made. And let it suffice to have given this notice concerning these matters.

From this newly discovered magnitude of the eccentricity I derived the equations of the Sun's motion [prosthaphaereses motus Solis] for each degree of the

eccentric, so that it could be established how much must be added to, or subtracted from, the mean and uniform motion throughout the whole circuit of the Sun's annual course, and so that thereby the Sun's true place, as seen from the Earth, the center of the universe, might become known. The method by which those equations were obtained is as follows.

Diagram. A large circle representing the Sun's eccentric, with a vertical diameter drawn from top to bottom and several chords meeting at two interior points near the center. The figure illustrates how the equation of the Sun's motion is found at three intermediate positions on the eccentric.

- A (top of the circle): the apogee [Apogaeum], where the vertical diameter meets the circumference at the top.
- I (bottom of the circle): the perigee [Perigaeum], where the vertical diameter meets the circumference at the bottom.
- B (upper left, on the circumference): the first intermediate position of the Sun, 30 degrees from the apogee.
- G (left, on the circumference): the second intermediate position of the Sun, at the place where the line drawn from the center of the universe perpendicular to the line of apsides meets the eccentric (the position of greatest equation).
- H (lower left, on the circumference): the third intermediate position of the Sun, 150 degrees from the apogee.
- C (interior, on the vertical diameter): the center of the eccentric [centrum Eccentrici].
- D (interior, just below C, on the vertical diameter): the center of the universe, that is, the Earth [centrum Mundi sive Terra].

Lines are drawn from B, G, and H each to C and to D. The short segment CD between the two interior points is the eccentricity.

Let the Sun's eccentric be understood, in the figure here set down, as the circle AGI, whose center is C, while the center of the universe — that is, the Earth — is D. Through these two points let a line be drawn until it meets the circumference of the circle on both sides; let this line be ACDI. It is then evident that CD is the eccentricity, which in our age — as we

have shown — is found to be 3584 parts, of the kind in which the semidiameter AC is taken as 100000. The Sun's place is to be understood as being either at B, or at G, or at H; for when it is at A or at I — that is, at the apogee or the perigee — it admits no equation at all, since it then coincides, at a simple place, with the true

place. From these three intermediate positions, then, let two lines be drawn from each of B, G, and H — one to C, the center of the eccentric, and one to D, the center of the Earth — and let it now be our pleasure to investigate the equation of the Sun's motion through these three positions.

Let the Sun first be at B, distant from the apogee by 30 parts, which interval is measured by the angle BCA. Therefore, in the triangle BCD, the angle at C is known, since it is the supplement of the former angle to two right angles, as is established from the elements of geometry; and in this case it is 150. The two sides containing this angle are likewise known: BC, the semidiameter of the eccentric, which is invariably taken as 10000000, and DC, the eccentricity previously determined as 358400 (for it was decided to keep it everywhere at this same value). Therefore, from the two given sides enclosing the known angle, the angle DBC will not escape anyone skilled in the science of plane triangles. This angle measures the equation of the Sun's motion itself — namely the difference by which the Sun's place appears otherwise from C than from D. By carrying out this operation I found it to be 0 parts, 59 minutes, 44 seconds, which shows how much must be subtracted from the uniform motion in order that the Sun's true place may be made clear.

In the same way, with the Sun placed next at H, at a distance of 150 parts from the apogee, in the triangle CHD the angle HCD will be, as the supplement of the foregoing, 30 parts. The sides enclosing it remain everywhere the same as before: HC, 10000000, and CD of the same kind, 358400; therefore the angle CHD will be given, 1 part 3' 33", which marks the equation of the Sun's motion at a distance from

the apogee of 150 parts — or, what is the same, 5 signs and 0 degrees — which is still to be subtracted. For throughout the whole prior semicircle, from A through G to I, the equation is subtracted from the simple motion, for the reason that there the Sun's true place precedes the mean; whereas in the rest of the circle, addition is required, for the contrary reason.

The greatest equation that can occur is at G — that is, at the position on the eccentric where the line drawn from D, the center of the universe, into the eccentric falls perpendicular to the line of the apsides, the apogee and perigee. We will investigate this in the following way.

Let there be a triangle CGD, right-angled at D, with the given side GC, 10000000, and CD, 358400, as before; since the angle at D is (as I said) a right angle, the angle DGC — which represents the greatest equation — will not be unknown: by

completed calculation it is 2 parts 3' 34" [P.2.1.3¼ — recte 2 parts 3' ¼? [?]]. The angle GCD, the complement of this to a right angle, is also given: namely 87 parts 56' ¾" [P.87.1.36¾ [?]], whose remainder to the semicircle shows the place where the Sun obtains its greatest equation — namely at a distance from the apogee of 92 parts 3' ¾" [P.92.1.3¼ [?]].

Following this preceding indication, we have fitted the equations of the Sun's motion to the individual degrees of distance from the apogee throughout the whole semicircle; for in the other part of the circle the positions equally remote from the apogee or perigee as the former ones keep the very same ratio.

[Margin: 6]

These equations nevertheless change gradually — not only the greatest, but together with it all the rest — nor do they remain the same in all ages; for through the careful observations of practitioners it has been noticed that, over a long stretch of years, the distance of the center of the eccentric D from the center of the Earth C varies somewhat. As a result, it becomes plainly necessary that the equations themselves likewise change along with it, just as the line

[Margin: 18]

[Margin: 23]

ACI also does not always remain in the same situation with respect to the equinoxes, but carries the Sun's apogee and perigee across into one place after another along the zodiac. Thus Hipparchus and Ptolemy reported from observations that the Sun's apogee in their time was under 5½ degrees of Gemini [sub 5½ II], and that the eccentricity was a twenty-fourth part of the semidiameter of the eccentric — that is, 415, of the kind in which the line from the center of the eccentric to the circumference is 10000. The greatest equation at that time was therefore 2 parts 10' [P.2.1.10].

[Margin: 9]

But because Ptolemy found these values to be the same as Hipparchus had found them by the same method an interval of 260 years before him, he supposed the Sun's apogee to be wholly immovable, and the eccentricity likewise to remain perpetually the same. Yet one may suspect that some error underlay the observations of both — or at least of one of them — which could easily happen in so delicate a matter, where the largest results are elicited from the smallest quantities; especially since they had set up the practice of this investigation by means of the solstitial transits, which are very difficult to observe, compared with

the equinoctial ones. And it is likely that Ptolemy, since he had not found so very great a difference, was unwilling to dissent from the values noted by Hipparchus, but chose rather to assign to his own age the same eccentricity of the Sun, and the same apogee, asserting both — too confidently — to be unmoved.

[Margin: 9]

Al-Battānī [Albategnius], however, whom they also call Muhammad al-Battānī of Raqqa [Muhammedem Aracensem], some 740 years after Ptolemy, found both of these to have changed perceptibly — so much so that the place of the apogee had advanced for him to 22 parts 17' of Gemini [P.22.1.17 II], and the eccentricity was found to be 2 parts 4' 45" [P.2.1.4.11.45], of the kind in which the semidiameter of the eccentric is 60; or, what is the same, of the kind in which it is 10000, the eccentricity being $346\frac{2}{3}$ [$346\frac{1}{2}$? [?]]; and from this is given a greatest equation of 1 part 59' $\frac{1}{3}$ " [P.1.1.59 $\frac{1}{3}$ [?]].

This same eccentricity, roughly 190 years after al-Battānī [al-Battānī], was found by Arzachel the Spaniard [al-Zarqālī]; but he detected the Sun's apogee earlier, at $4^{\circ}\frac{1}{2}$, although here (as I said) it must in fact have been later in his time. So which of the two should be trusted, or rather which one, has remained in doubt until now. With God's favor, I shall settle this dispute in its proper place and time.

At last, long after these men, Nicolaus Copernicus of Toruń [Copernicus], around the year of our Lord 1515, supposed he had correctly determined the Sun's apogee at $6^{\circ} 40'$ of Cancer $\mathfrak{S}$, and its eccentricity at 323 parts (of those of which the semidiameter of the eccentric is 10000), that is, 1 part 56', or as it were 60 parts 1' 0"; and from this he gathered a maximum prosthaphaeresis of 1 part 1' 51". But here that supreme man — otherwise most deserving in the restoration of astronomy — went intolerably astray. For it is impossible that, by our own times, this eccentricity should have been so suddenly increased to such a degree, and that the apogee should have retreated backward by more than a whole degree. By our own observations, and by the demonstrations deduced from them, no error whatever underlies the solar apogee and eccentricity, and the matter deserves no controversy at all. Moreover, the excellent observations of Bernhard Walther [Bernhard Walther], the most distinguished citizen of Nuremberg and a pupil of the famous Regiomontanus [Regiomontanus] at Nuremberg, made a little before the time of Copernicus (of which I shall say more later), bear witness that no small error underlies these Copernican findings. But why so distinguished a man as Copernicus should have erred so enormously in the Sun's apogee and eccentricity — indeed in its whole course, and in the things to be drawn from this — I shall now show the reasons, since they are perhaps not obvious to everyone.

[Margin: 13]

On the Occasion of Copernicus's Error in the Sun's Apogee and Eccentricity, and on Marking Out Exactly its Whole Course

First, he perceptibly deviated regarding the elevation of the pole at his own location, assuming it somewhat too small — as I myself made trial of the matter. For when, from careful observations taken over several years of the Sun's motion, I had a thorough grasp of Copernicus's figures, and they by no means corresponded precisely to the heavenly standard in his system — the discrepancy sometimes amounting to more than half a degree — I conceived no uncertain conjecture: that he had set the elevation of the pole at his place of observation nearly three scruples too small. This was thereafter easily confirmed, since he established the maximum declination too small by almost three minutes as well. Hence, since he derived the polar elevation from the Sun's maximum and minimum altitudes — that is, from its maximum declination — it is clear; and he failed to take into account the role of refraction in the situation near the winter solstice (where at Frauenburg the Sun is raised at least 12 degrees), which makes the Sun's position appear at least eight minutes higher than it really is.

So that I might be quite certain the whole matter stood thus, and that I had verified an error so perceptible — committed by Copernicus in the polar altitude of his location — I sent, four years ago, namely in the year 1584 now elapsing, a certain studious young man named Elias Olai [Elias Olsen Morsing], devoted to and serving me in astronomical exercises, to Frauenburg in Prussia. I entrusted to him an exquisite instrument of ours, well fitted and exceptionally capable of capturing all the scruples, with which he might investigate the pole's elevation there. He went in the company of my old and most noble friend Levin Bülow [Levin Bülow], chief councillor of the illustrious and most noble Prince, the Margrave of Ansbach, who had discharged the office of legation to our most serene and most powerful King; and, conveniently brought there by the royal ship returning to its prince, he stayed a full month at Frauenburg in Varmia. He was kindly and graciously received by the noble Canons of that place, and, having obtained the convenience of the location for carrying out reliable observations, he secured very many careful observations on each clear occasion: by day on the meridian Sun raised in the northern semicircle (and on that account not subject to refractions), and by night on the stars, taking observations of their altitudes by the aid of the same instrument. From all of these, after he had returned home to

me, I gathered beyond doubt that the polar altitude of Frauenburg, where Copernicus lived, is 54 parts $22\frac{1}{4}$. This was done by comparing the altitudes of the Sun and of the stars with the declinations, both by that very instrument and also by other instruments found here in the same year. Nor is there any reason for anyone to suspect that this apparatus contracted some fault on the journey. For it was carefully protected in a suitable case, and when it had been carried back here by ship, it gave exactly the same altitudes

and distances of the stars that it had yielded before (for it was permitted to measure both by this instrument), so that no doubt whatever remains that the polar altitude of Frauenburg was determined precisely in this way, and that it is $22\frac{3}{4}$, exceeding the Copernican record by nearly the same interval — a thing I had long silently suspected, even before I undertook to test the matter by experience. It is plain, therefore, that everywhere in the Sun's declinations Copernicus deviated by three scruples, less one quarter; and this also makes the solar ingresses at the equinoxes themselves vary by as many hours, and extends the interval between the vernal and autumnal equinox by $5\frac{1}{2}$ hours, further than he supposed. Thus too he used the Sun's maximum declination, constrained too tightly by nearly three scruples; for at the places intermediate between the solstices and equinoxes the Sun's motion, when derived through the declination, departs somewhat from the true position. There is also this further, not least, occasion of error: that he referred the Sun's ingresses to the middle of the equinoctial parts, where the Sun, still situated rather low on that sloping horizon, has an altitude of at least $19\frac{1}{4}$, and hence is subject to a refraction of at least 4 minutes; and since he did not guard against this, he renders the Sun's declination there too small by just that much. But this matter, behaving differently near the middle of the equinoctial part by nearly four scruples, changes the longitude by about 13 minutes, which is then scarcely completed in five hours; and so much, too, does it abound by reason of refraction at the ingress to the 15th degree of Scorpio according to Copernicus. Not to add that the Sun undergoes a certain amount of refraction not only near the middle of the equinoctial part, but also near the beginnings of Aries ♈ and Libra ♎, though it does not present itself very perceptibly. It would therefore have been far more satisfactory had he set up the calculation at the middle of the signs Taurus ♉ and Leo ♌; for there the Sun, on account of its great altitude, is then free of any perceptible refraction. And for this reason, lest we ourselves strike against the same reef of error, we passed over the middle of the equinoctial parts and directed our observations and calculation to those higher places in the middle of Taurus ♉ and Leo ♌. Nonetheless Copernicus seems not to have neglected the Sun's parallax in his observations, as is partly gathered from the fact that his record differs so greatly from the interval

observed by us from Aries ♈ to Libra ♎; for if he had not applied the parallax, this discrepancy would certainly have been smaller, since parallax and refraction nearly cancel each other out, so that on this account the Sun's motion would have been found not so far from the truth, and consequently the intervals of the equinoctial quadrants would stand more correctly. This is partly gathered also from what that most learned mathematician Georg Joachim Rheticus [Rheticus], Copernicus's pupil, says in the narrative added at the end to the Copernican work, addressed to Johann Schöner [Johannes Schöner]: that the ancients did not know the exact reckoning of the sidereal year, and for this cause too — namely, because, being ignorant of the certain reckoning of eclipses, they neglected the diversities of the aspects of the Sun, from which these are at last derived. From this one may gather that Copernicus himself clearly perceived this error, that his teacher had inclined toward it, and that he applied the Sun's parallax to the observed altitudes.

[Margin: 10] [Margin: 21] [Margin: 33]

And with these causes concurring together, it is no wonder that Copernicus prescribed the standard of the Sun's course less exactly, and so greatly departed from the intended mark in establishing its apogee and eccentricity. For we too, if by like reasoning, neglecting the solar refraction but nevertheless applying the parallax, investigate everything — even so the Sun's eccentricity will be found to be 1 part 58', which does not depart much from Copernicus's view; and the apogee, too, will be carried out further than before. But this finding, for the reasons stated above, lies open to a perceptible error. I say nothing now of the fact that Copernicus did not have at hand astronomical instruments skillfully wrought of solid metal and of suitable size, perfected in every respect with all that is required for this purpose — as may be gathered from the parallactic instrument made by him and used in practice, which the noble and learned man Johannes Hannovius [Johannes Hannow], a Canon of the same place, sent me as a gift through the aforesaid studious young man. For although it is of fairly ample size, fully a four-cubit measure, it is nevertheless entirely of wood, and made of fir — a material not free of warping and change — and it has its divisions marked off not very finely in ink; it also has apertures too large, through which the rays of the Sun and stars are not admitted accurately and reliably enough. So that on this account, even if Copernicus used no other instruments in deriving the altitudes of the Sun and stars from the heavens, it might seem no wonder that he still departed by a rather large interval from the proposed goal. I think nonetheless that he examined these same things with several instruments, and did not entrust so subtle an investigation to these rules alone; but the full and

requisite precision in these matters he did not bring to bear, as many other things attest. This concerning the occasion of Copernicus's error in the Sun's apogee and eccentricity, and in disposing its motion, may suffice to have said. I have decided that these things should be pointed out so that it might be clear how it came about that so great an astronomer otherwise — proceeding from a false apogee and eccentricity — established a mean motion of the Sun so true and yet so erroneous, from which it follows that the things bearing on the length of the year, both sidereal and tropical, and on the progression of the equinoxes, derived from this very point, stand less correctly. Indeed, in the courses of the remaining planets too, insofar as they necessarily regard the simple motion of the Sun, no slight error creeps in from this source. Hence it is plain what and how great are the aids to establishing astronomy precisely that the dimension and reckoning of the Sun's path, not explored to the exact rule, shuts off from us.

[Margin: 1] [Margin: 10] [Margin: 20] [Margin: 30] [Margin (handwritten): de hora p. 80, lin. 18]

Now we shall proceed to delimit the Sun's simple motion more accurately and more subtly than before — that very motion which we assumed in investigating the apogee and eccentricity, since for a few annual revolutions at least it is sufficient.

[Margin: 34]

My aim is to lay bare the Sun's apparent motion over the course of three or four centuries — that is, the next few ages immediately to come. For whatever variation in the eccentricity may occur in the meantime will be extremely slight, and it will not produce any appreciably different motion of the Sun from the one we shall establish. But in order to arrive at a more exact account of the Sun's mean motion, it will be worth the effort to determine the length of the year more precisely than before — a length, that is, that agrees exactly, at least for these present ages. In this matter no small difficulty lies hidden. For the tropical year, which is reckoned from the equinoxes or the solstices, exhibits a certain inequality, as the observations of astronomers separated by long intervals of time bear witness. [Margin: 10] Thus from Hipparchus [Hipparchus] to Ptolemy [Ptolemy] one magnitude for this year is found, a different one from Ptolemy to al-Battānī [al-Battānī], and one still different from both of these down to our own time — as we shall now set out for inspection.

The unequal lengths of the equinoctial or tropical year, collected from the observations of various astronomers separated by long intervals of time.

		H			
		Dies.	.	'.	".
From Hipparchus	to Ptolemy	365	5	55	12
From Ptolemy	to al-Battānī	365	5	46	20
From al-Battānī	to our own Observations	365	5	49	29
From Ptolemy	to our own Observations	365	5	47	52

From these figures it is sufficiently clear that the magnitude of the year measured from the equinoctial or tropical points is unequal — even if the discrepancy that arises by reason of the changing apogees and eccentricity is guarded against. This guarding-against is done by everywhere assuming the Sun's simple motion at the equinoctial points; given the apogee and eccentricity of that epoch, this simple motion can readily be established [Margin: 24] from the true

motion, which is yielded at the beginning of Aries ♈ and Libra ♎ from the actual observation of the equinoxes. And in this way the times prescribed here have been arranged by us, by means of a uniform motion of the Sun, more precisely than before. From this it has come about that we have assigned a year-length between Ptolemy and al-Battānī slightly smaller — by four seconds, namely — than al-Battānī himself did. He, indeed, compared the true positions of the Sun at the autumnal entries with one another, whereas it would have been safer and more correct to have employed the mean and simple positions.

[Margin: 10] But the chief explanation of the inequality of the years — even in this method, arising from that irregularity which occurs by reason of the changing apogee and the eccentricity, once these have been allowed for — derives from the fact that the equinoctial points recede unequally from the fixed stars. [Margin: 14] For when the comparison is made with respect to the fixed stars, the annual restitution, as regards the simple motion of the Sun ☉, is found to be perpetually constant and regular. Copernicus [Copernicus] — a man of lofty genius and judgment — observing this, referred the reckoning of the motions, both of the Sun and of the other planets, to the sphere of the fixed stars. I also believe that this method was in use among the most ancient astronomers in Egypt and Babylonia and the neighboring regions, even though Ptolemy did not hesitate to set it aside as unsuitable — and on this point, Copernicus rightly judged that he should not be heeded.

[Margin: 24] And although some discrepancy among astronomers is found even in this very magnitude of the fixed and sidereal year, it is nevertheless not to be put on a level with the former discrepancy, the one that proceeds from the

equinoxes. For this can arise either from a fault in the observations, or because some of these astronomers did not allow for the parallax and refraction of the Sun, or perhaps because they did not apply a sufficiently precise investigation [recte: inquisitio] to the positions of the fixed stars

— or rather from all of these causes occurring together; and this could easily happen in so delicate an inquiry, where great results are gathered from the smallest quantities. Therefore we shall first set out what the ancients and Copernicus established for defining this length of the year. Then we shall present it corrected afresh by comparing it with our own observations against the Ptolemaic ones, and competently measured.

The most ancient Egyptians and Babylonians, according to al-Battānī (*On the Science of the Stars*, Chapter 27), determined this sidereal year — that is, the restitution of the Sun annually to some fixed star — to be, beyond 365 days, a quarter of one day, and in addition a 131st part, which together make up 15 minutes, 27 seconds, 30 thirds of a day; or what comes to the same thing, 6 hours, 11 minutes, 0 seconds.

Thābit ibn Qurra [Thābit ibn Qurra], the son of Qurra, as Copernicus reports, declared the length of this year to be, beyond 365 days, 15 minutes, 23 seconds of a day, which amount to 6 hours, 9 minutes, 12 seconds.

Copernicus himself, examining these figures and correcting them from his own observations, established the sidereal year at 365 days, 15 minutes, 24 seconds, 10 thirds of scruples — so that Thābit's annotation falls short of his own by at least $1\frac{1}{2}$ seconds of a day. This year-length, when resolved into hours and their fractions, comes out at 6 hours, 9 minutes, 40 seconds after the whole days, which exceeds Thābit's finding by only 28 seconds of one hour.

We therefore, in order to find some more exact account of this annual length — since indeed so much depends upon it that not only the Sun's apparent motions but those of the other planets too hang upon it to some degree — diligently compared the Ptolemaic observations of the Sun and the fixed stars with our own,

for I am persuaded that his observations are more exact and reliable than the Hipparchan ones. And in order that the entanglement which arises from the changing apogee and eccentricity should not stand in our way, we have referred the whole comparison to the Sun's simple motion in both cases, as we shall now make clear.

[Margin: 6] We take, then, the autumnal equinox observed by Ptolemy at Alexandria, in the 17th year of the Emperor Hadrian, on the 7th day of the month Athyr, at 2 hours after noon, according to the Egyptian reckoning. This falls in the running year from the birth of Christ 132, a bissextile year, on the 25th day of the month of September, likewise at the second hour after noon — and this according to the Roman reckoning of Julian years, which we still use today. Reducing the hours to our own meridian, the time after the noon of the said 25th of September will be at least 0 hours, 25 minutes; for in this place we are more westerly by 1 hour and 35 minutes. If we now apply to this the other autumnal equinox carefully observed by us in the year 1588, likewise a bissextile year, on the 12th day of September, at the hour $15\frac{1}{4}$ after noon, there will have elapsed from the former up to this one of ours 1455 Julian years and, in addition, 353 days, 15 hours less $\frac{1}{6}$. The Sun's simple motion for the time of each observation will accordingly be given as follows.

Diagram. A circle with center C, representing the eccentric. A vertical diameter runs from A at the top through the interior to the bottom of the circle. Near the center, slightly below it, point C is marked, with point D just beneath C on the vertical line. Point B lies on the lower-left of the circumference. Two lines are drawn from B: one to C and one to D, forming a narrow angle at B. The vertical line A–(C/D)–bottom is the line of apsides; the angle ADB is the figure under discussion (the true place of the Sun reckoned from the apogee).

- A (top of circle, on the vertical diameter): apogee end of the line of apsides
- B (lower-left of circumference): position of the Sun on the eccentric
- C (just above center, interior): center of the eccentric circle
- D (just below C, interior, on the vertical line): center of the Earth / observer's point [?]

The text beside the figure reads: First, for the Ptolemaic equinox: because at that time the Sun's apogee was situated in $5\frac{1}{2}^\circ$ Gemini Π , and the eccentricity was 2 parts $29\frac{1}{2}$ minutes [P.2./. $29\frac{1}{2}$] of the kind of which the semidiameter of the eccentric is 60 — there will be, in the figure assigned, the angle ADB, which is the distance of the true place of the Sun from the true apogee; which

which is the same as the angle BDC in the triangle BDC. Here, therefore, together with the two sides DC (given through the known eccentricity, P. 2. 1. $29\frac{1}{2}$) and BC (the semidiameter of the eccentric, in the same units, 60 parts), we have these data. And so, since two sides are given along with one angle, the angle DBC will not stay hidden: P. 2. 1. 10, very nearly — the prosthaphaeresis by which the simple motion differs from the true. This is to be added to the observed place of

the Sun itself at the beginning of Libra (♎), because the apparent motion precedes the simple motion. The result is the mean place, reckoned from the vernal equinox for the time of Ptolemy's observation, Sign 6, P. 2. 1. 10. If from this you subtract the precession of the equinoxes — which at that time stood according to Ptolemy's tenets, P. 6. 1. 36 — there results the simple motion of the Sun from the first star of Aries (♈), Sign 5, P. 25. 1. 34.

For in the second year of Antoninus, on the ninth day of Pharmuthi (which is the eighth of the Egyptian months, and which falls about the end of February of the year of Christ 139 then current), Ptolemy [Claudius Ptolemy] observed Regulus at P. 2. 1. 30 of Leo (♌) by means of armillae, comparing it with the Sun through the mediation of the Moon. And since he places the first star of Aries (♈) preceding the Heart of Leo (♌) [Regulus] by $115^{\circ} 50'$ in ecliptic longitude, that first star of Aries was at that time at the same point as the first star of Aries, namely at P. 6. 1. 40 of Aries (♈) — the point from which Copernicus [Copernicus] measures the precession of the equinoxes. If this is carried forward to the time of the autumnal equinox of the year 132, which we now use, an interval of 6 years and 7 months had elapsed, to which there corresponded at that time, in the motion of the fixed stars, 4 minutes very nearly, because in that age they advanced one degree in a hundred years. And so in September of the year 132 then current, by this Ptolemaic reasoning, the precession of the equinoxes was, as I said, P. 6. 1. 36.

ANNOTATIO AVTHORIS. [Author's Annotation.]

In this passage we have assumed the precession of the equinoxes according to that interval which, in Ptolemy, runs from the Heart of Leo (♌) to the first star of Aries (♈), P. 115. 1. 50.

namely, that this should rather correspond to the observation of the declination of Spica Virginis (♍) noted by Ptolemy for about the same time, P. $0\frac{1}{2}$ North, by which its longitude is set down at P. 26. 1. 40 of Virgo (♍). For since Spica, according to its longitude in his work, is distant from the first star of Aries (♈) by P. 170. 1. 0, the aforesaid precession of the equinoxes results; and thus the Heart of Leo (♌) [Regulus] must be set further on by a sixth part of a degree, namely at P. 2. 1. 40 of Leo (♌), its distance from the first star of Aries (♈) then coming out at P. 116. 1. 0 — which tends still closer to the mark. For in the heaven itself they are even now removed by more than this longitude, namely by P. 116. 1. 41. And in this way the interval between Spica Virginis (♍) and the Heart of Leo (♌) comes out as P. 54. 1. 0, and this agrees well enough with celestial observation, which gives it as P. 53. 1. $58\frac{1}{2}$. Indeed it does not differ much at all from his own annotations made in the year 139 (as I said), if everything is carefully delimited,

as we shall show elsewhere, when we shall examine this whole matter — both through Spica and through the Heart of Leo (ϱ) — somewhat more accurately. I pass over now the fact that, if the true distance of the first star of Aries (γ) from Spica that holds in the heavens, P. 170 $\frac{2}{3}$ nearly, be applied, the precession of the equinoxes must still be drawn back two-thirds of a degree further. Yet this poses no obstacle in this place, since in both cases we are applying the Ptolemaic difference.

In our other intersection [adversio], however, since the apogee of the Sun is at 5 $\frac{1}{2}^\circ$ of Cancer (ϑ) toward A, and the eccentricity DC is P. 2. 1. 9, in units of which BD is P. 60. 1. 9, the angle of the distance of the true place from the apogee, ACB, will be P. 84. 1. 30 — which is the same as the angle BCD in the triangle BCD. And since in this same triangle two sides are given (as was just said), the angle DBC will not stay hidden, the prosthaphaeresis which holds at this time as the Sun enters Libra (φ): it is P. 2. 1. 2 $\frac{1}{2}$. If this is added to the true place of the Sun ($\odot$) observed at the beginning of Libra (φ), it will yield the simple or mean motion of that same Sun from the vernal equinox, Sign 0, P. 2. 1. 2 $\frac{1}{2}$. And if from this in turn the precession of the equinoxes is subtracted — which at this very time, from our observations, is P. 28. 1. 5 $\frac{1}{2}$, as in the following Chapter we shall make known from sure considerations held on the matter — (understand here that, if the first...

Diagram. A circle (the eccentric) with the apsidal diameter drawn vertically as a straight line from A at the top to E at the bottom. Two interior points, D and C, lie on (or near) the vertical diameter below the center region, with D above C. The point B sits on the left of the circumference. Straight lines are drawn from B to A (along the upper part of the diameter region), from B to D, and from B to C, forming the triangle BCD used in the prosthaphaeresis computation. This is the eccentric-circle construction for the Sun's second equinox intersection (apogee at A, the Sun's place at B, eccentric center C, Earth at D).

- A (top, on the circumference): upper endpoint of the apsidal diameter (the apogee, *Apogaeum*)
- B (left, on the circumference): the Sun's place
- C (interior, below D): center of the eccentric
- D (interior, above C): the Earth's place (observer)
- E (bottom, on the circumference): lower endpoint of the apsidal diameter (the perigee)

the first star of Aries (Υ) be assumed, in the Ptolemaic manner, to precede Spica Virginis (♍) in longitude by P. 170. 1. 0; for otherwise the truer precession of the first star of Aries, with respect to the vernal equinox in this year, is G. 27. 1. 26.) There will result the mean place of the Sun ($\odot$) at the position of the fixed stars, and this, reckoned from the said first star of Aries (Υ), is Sign 5, P. 3. 1. 57. If I subtract this from the prior Ptolemaic value, which was Sign 5, G. 25. 1. 34, we shall detect that the simple motion of the Sun, with respect to the orb of the fixed stars, beyond the complete revolutions — 1455 of them — has accomplished P. 338, 1. 23.

And so, from these data, according to the correspondence of proportions: if the Sun in mean motion, starting from some non-wandering star, in 1455 completed Julian years and 353 days, 14 hours, 1. 50, has gone through 1455 circuits and, over and above, 338 parts and 23 minutes, it follows that in one day it is moved by the portion which stands thus:

Motus Solis diurnus à prima Υ iuxta recentem verificationem. [The Sun's daily motion from the first star of Aries, according to the recent verification.]

P.	1.	11.	111.	1111.	V.	V1.	V11.
0	59	8	11	27	14	26	54

And this exceeds Copernicus's computation by nearly 5 fourth-order minutes [quartis scrupulis], while from Ptolemy up to now there are wanting, by the same reckoning, $12\frac{1}{2}$ minutes — so that likewise the remaining Ptolemaic equinoxes, when compared with ours by the same method, attest to it as closely as possible; so much so that from him up to now, over so many years, the simple motion of the Sun with respect to the fixed stars can scarcely stand otherwise than by $\frac{1}{2}$ a minute, this way or that, which is hardly perceptible. We have, moreover, chosen this equinox in preference, because it holds itself in a middle position, within our procedure, with respect to the remaining two that were observed by us — namely the autumnal, which he recorded in the year of Christ 139, on September the 26th day, H. 7 from the preceding midnight; and the vernal, in the year 140, on March the 22nd day, H. 1 P.M., at Alexandria [Alexandria] — and these, if the years themselves, Egyptian, reckoned from Alexander the Great [Alexander the Great], be reduced to...

Julian years from the birth of Christ, so that there be no doubt that the simple daily motion of the Sun, with respect to the fixed stars, established by comparing the more select Ptolemaic observations with ours, has been settled correctly

enough. And from this there results the same mean place of the Sun in a common Julian year: Sign 11, P. 29. 1. 44. 11. 49. 111. 40. 1111. 42. V. 53. V1. 38. V11. 30. This too exceeds Copernicus's calculation — even as corrected according to Reinhold's [Erasmus Reinhold] limitation — by a little more than half a second [scrupulo secundo], which is indeed too much for a single revolution; for in the course of many years this error, though it may seem slight, turns out to be quite fertile. And if, in addition, we add the motion of one day, there will result the course of a bissextile year: Sign 0, P. 0. 1. 43. 11. 57. 111. 52. 1111. 10. V. 8. V1. 5. V11. 24.

And from this the Tables of the mean motions of the Sun with respect to the Eighth Sphere [sphaera octava] will easily be able to be gathered — and many things necessary for the circuits of the remaining planets to be constructed. Moreover, if we divide this same daily motion of the Sun, thus found, through a whole circle, P. 360, there will result a quantity of the sidereal year that is more correct and better accommodated to the Ptolemaic positions, as follows.

Verior è proprijs Observationibus cum Ptolemaicis collatione facta, Anni Siderei dimensio. [A truer measure of the sidereal year, made by comparing our own observations with the Ptolemaic ones.]

D.	H.	1.	11.	111.
365	6	9	26	43½

Now this year, ordered in this way, falls short of Copernicus's finding indicated above by 11. 13. 111. 16½, but exceeds the Thābitian [Thābit ibn Qurra] annotation by 11. 14. 111. 43½ — so that our determination is nearly intermediate between the two assumptions, yet comes a little closer to Copernicus's tenets. And this magnitude of the sidereal year, derived in this way from Ptolemy down to us, is indeed the more certain — which is also confirmed by the al-Battānian [al-Battānī] observations of the Sun and stars...

does not differ greatly from the sidereal motions of the stars, provided that they are applied correctly and by the particular method required.

But since I am not now attempting a universal restitution of the Sun's motion valid for every age — for I have decided to reserve that whole labor for the complete *Work of the Restoration of Astronomy* — but only one such as will suffice for these centuries nearest to us, within 300 or 400 years, this is enough; for in the meantime no such great inequality can arise in the tropical year as would disturb my purpose. For this reason I shall not here use the sidereal year, which requires that the intricate theory of the precession of the equinoxes be

unraveled at the same time. To do that in this place would be far too long-winded, and would make me wander further than is right beyond my proposed subject. I shall therefore rather be content with the equinoctial or tropical year as verified for these very times. I shall investigate it from the observations of that most learned man Bernhard Walther [Bernhard Walther] of Nuremberg — a man worthy of perpetual remembrance and praise, and outstanding above all as a pupil of the celebrated Regiomontanus — observations of the meridian altitudes of the Sun made at Nuremberg a hundred years ago. By selecting his more careful records I shall examine the matter in the following way.

First of all, it is necessary that we know precisely the altitude of the pole in the famous city of Nuremberg, where the said Walther lived and obtained his observations. This we shall achieve by a particular method from those very Waltherian meridian altitudes at both solstices, especially the more accurate ones.

Having compared and examined together all his recorded distances of the chords from the vertex, which the same Walther measured over several consecutive years in his own day at Nuremberg, I find

I find that at the summer solstice the least distance from the vertex occurred, taking the principal observations as my limits, at a chord of 44884 (the whole sine being 100000), to which corresponds an arc of P. 25. l. 56¼., manifestly showing the apparent distance of the Sun from the zenith of the head. The complement of this to the quadrant is the apparent altitude of the Sun itself, P. 64. l. 3¾.; and if to this is added the parallax occurring at that height, min. 1¼., the true greatest elevation of the summer solstice at Nuremberg will come out as part. 64. l. 5 exactly.

Likewise, at the least altitude in winter the chord is 118800, to which corresponds an altitude of the Sun of P. 17. l. 7. ll. 2.; and with the parallax, which is l. 2. ll. 58., added, the same comes out as P. 17. l. 10.

From these given altitudes at both solstices, the elevation of the Nuremberg pole is found — if the parallax is neglected — as part. 49. minut. 24½. very nearly, together with the greatest declination of the ecliptic from the equator of part. 23. minut. 28½.. These same values the same Walther and several of his successors used as if they were correct, leaving the seconds aside. But if the parallax is applied, this same greatest declination will come out as P. 23. l. 27½., and the altitude of the pole will then be P. 49. l. 22½.. Yet neither of these reckonings supplies the exact position of the Nuremberg pole, nor even the greatest

declination in proper measure, and that because of the refraction neglected at the winter solstice in the low declivity.

Another way must therefore be entered upon, so that the obstacle of refraction may be guarded against — a way that will be of the following kind. Through the instruments of the most illustrious prince William, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel] — a man excellently versed in astronomical matters, and for his advancement of them worthy of all praise above the other princes of Europe — it was found, as his Highness wrote to me, that...

his Mathematician, Christoph Rothmann [Christoph Rothmann], skilled in these arts, found the greatest meridian altitude of the Sun at Kassel to be exactly P. 62. l. 11., and the least P. 15. l. 14.. If, then, the parallax is applied in both cases, the true altitude of the summer tropic at the meridian will be P. 62. l. 12 $\frac{1}{3}$., and of the winter P. 15. l. 17.; and the inclination of the equator there, derived from the circumpolar stars, comes out as P. 38. l. 41.. Therefore the obliquity of the ecliptic with respect to the summer solstice will be P. 23. l. 31 $\frac{1}{3}$., agreeing well enough with my own finding. This, subtracted from the elevation of the equator, leaves the true winter altitude of the Sun as P. 15. l. 9 $\frac{2}{3}$., which falls short of the earlier value found by observation, once the parallax of l. 7 $\frac{1}{2}$. has been applied; and so great is the refraction of the Sun there around the winter solstice in the lowest declivity.

But because Nuremberg is nearly 2 degrees more southerly than Kassel itself — whence it also makes the Sun so much higher at the winter solstice, and consequently somewhat less subject to refraction — therefore, leaving aside that third adhering part of a scruple, let us fix the refraction at Nuremberg in winter precisely at minut. 7., which cannot perceptibly differ from the truth. The exact least altitude of the Sun there will therefore be, with these 7 minutes subtracted, P. 17. l. 3.. And since the highest (as I said before) is P. 64. l. 5., the interval of the tropics comes out as P. 47. l. 2.; and therefore the greatest declination is P. 23. l. 31., at least smaller by half a scruple than it is now found to be. For it seems reasonable that the obliquity of the ecliptic has grown a little since that time, in that the eccentricity of the Sun ☉ has also meanwhile been somewhat increased, and is not (as the Copernican reasoning idly maintains) being diminished — as will be evident from what follows shortly. But when this greatest declination is subtracted from the true meridian altitude of the summer solstice, or added to the corresponding altitude of the winter tropic, in the way I have said...

in the corrected way, a truer inclination of the equator at Nuremberg will result, P. 40. l. 34.; and therefore the elevation of the pole will be P. 49. l. 26.. This was the point worth investigating by such a reckoning.

That this polar altitude agrees quite precisely with the city of Nuremberg, I have no doubt at all, seeing that it yields the declination of the ecliptic so suitably along with it. And although I have not yet taken care to make the test there through my own instruments, as at Frauenburg — because the larger instruments cannot easily or safely enough be carried by wagon — nevertheless I have resolved (God willing) to try it before long, so that I do not distrust that this value which I have assumed will scarcely deviate by a quarter of a minute from the truth, either short or beyond it.

[Margin: 10]

Just as at Frauenburg in Prussia, before I had its exact altitude examined (as was said before), I had guessed it within a quarter of a minute correctly, even though I was not equipped there with such frequent and solid documents as here. Nor does it detain us that several distinguished astronomers of Nuremberg have for the most part used an altitude of the pole of part. 49. minut. 24.; for these men, deriving it from the Sun, had account neither of parallax nor of refraction, as they ought to have had. Indeed, I find that the most learned man

[Margin: ✓]

Andreas Schöner [Andreas Schöner], in his laborious work on gnomonics, set the latitude of Nuremberg, his native city, at P. 49. minut. 27., which exceeds my finding by only a single scruple as yet. It is likely that he derived this from the circumpolar stars, in imitation of the method which he had seen used by the most illustrious prince William, Landgrave of Hesse — of whom he also makes mention in his *Treatise on the Discovery of the Meridian Line*, which is attached there near the end. But as to the fact that this altitude with him is by one minute...

by a minute beyond our own value, this could easily have arisen from a fault in the instrument or in the observation. And since the most learned man's result exceeds ours, and is by no means less, this confirms all the more that our determination does not overstep the proper limit — even if it slightly surpasses the values that others have derived by means of the Sun. The elevation of the pole at Nuremberg, then, we have now investigated with sufficient precision, and we hesitate over it no longer. We shall now turn to the Sun's apogee and eccentricity [Apogaeum et Eccentricitas], for whose sake we have undertaken this inquiry,

and we shall set out to derive them from the aforementioned observations of Bernhard Walther [Bernhard Walther].

[Margin: 10]

After I had examined, with great care and circumspection, the said Bernhard's chords of the distances from the vertex — taken on certain days over a span of several years, by the accepted Ptolemaic rules [Regulae Ptolemaicae], and that more than a century ago, especially in the year of Christ 1488, together with several years before and after — by comparing, that is, and delimiting the choicest observations of many years, I found that, over the full century now elapsed, the interval of time from the Sun's entry into the vernal equinox up to the following autumnal equinox was D. 186. H. 17. l. 49 [186 days, 17 hours, 49 minutes]; that from the beginning of Taurus to the middle of Scorpio, 46 completed days, H. 3. l. 35 [3 hours, 35 minutes]; and, moreover, that from the middle of Leo to the beginning of Libra, D. 46. H. 8. l. 50 [46 days, 8 hours, 50 minutes]. From these data, if we work out the Sun's apogee and eccentricity for the hundredth year just past, by the same method of reasoning that we used before (which is everywhere to be understood as applying here), everything will emerge duly assembled by the calculation of the demonstration. As before, in order and in summary, with the earlier diagrams applied, it will lie open to the eye at a single glance in the arrangement that follows.

Diagram. Two companion circular geometric figures stand side by side at the top of the page, each enclosed in a ruled frame above its own table of computed values. Each is an eccentric-circle construction for deriving the Sun's apogee and eccentricity from the three seasonal arcs. In both, the circle carries cardinal points around its rim, a center marked E, and chords drawn between the rim points and the interior points.

Left figure:

- H (top): upper rim point
- Q (upper right): rim point (the Sun's position)
- L (left): rim point, marked with the Libra/equinox sign
- Y (right): rim point, marked with the Aries sign
- P (lower left): rim point
- O (bottom): lower rim point
- E (center): center of the circle
- V (just right of center): interior point
- R (left of center): interior point on the horizontal diameter

Right figure (mirror arrangement):

- H (top): upper rim point
- Q (upper left): rim point (the Sun's position)
- L (left): rim point, marked with the Libra/equinox sign
- Y (right): rim point, marked with the Aries sign
- P (lower right): rim point
- O (bottom): lower rim point
- E (center): center of the circle
- V (just below/left of center): interior point
- R (right of center): interior point on the horizontal diameter

Beneath the two figures are two parallel tables of computed quantities, each headed by three columns: **P.** (degrees), **l.** (minutes / first part), **//.** (seconds / second part). Some entries (chords, sines, lines) are long pure numbers spanning the value columns rather than degree-minute-second triples.

Left table:

Quantity	Label	P.	l.	//.
Arcus	T Q	45	29	13
Arcus	T H L	184	3	21
Arcus	L P O T	175	56	39
Angulus	T E Q	45	0	0
Angulus	Q P T	22	44	37
Angulus	P E T	135	0	0
Angulus	L T P	22	15	23
Arcus	P L	44	30	46
Arcus	P O T	131	25	53
Chorda	P T	18230300		
Arcus	P O Q	176	55	6
Chorda	P Q	19992768		
Angulus	P E R	45	0	0
Sinus eius		7071068		
Sinus	P T R	3787518		
Ergò	P R	6904759		

Quantity	Label	P.	l.	//.
Linea	P E	9764803		
Compl.	P O T Q	3	4	54
Huius Sinus		537594		
Ergò	Z V	268797		
Chorda	E Q	10227965		
Linea	Q V	9996384		
Latus	E V	231581		
Angulus	Z E V	49	15	10
Latus	Z E	354807		

Right table:

Quantity	Label	P.	l.	//.
Arcus	Q L	45	42	9
Arcus	T H L	184	3	21
Arcus	L O T	175	56	39
Angulus	L E Q	45	0	0
Angulus	Q P L	22	51	4
Angulus	L E P	135	0	0
Angulus	E L P	22	8	56
Arcus	T P	44	17	52
Arcus	L O E [?]	131	38	47
Chorda	P L	18245698		
Arcus	P O Q	177	20	56
Chorda	P Q	19994646		
Angulus	P E R	45	0	0
Sinus eius		7071068		
Sinus	R L P	3770147		
Ergò	P R	6878895		
Linea	P E	9728226		
Compl.	P O Q	2	39	4
Sinus eius		462542		

Quantity	Label	P.	l.	//.
Ergò	Z V	231271		
Chorda	Q E	10266420		
Linea	Q V	9997323		
Latus	E V	269097		
Angulus	Z E V	40	40	40
Latus	Z E	354817		

It follows, therefore, from the first inference — the one that proceeds from the equinoxes to the middle of Scorpio — that the eccentricity Z E comes out as P. 2. l. 7. //. 43 [2 degrees, 7 minutes, 43 seconds], in the units in which the semidiameter of the eccentric is 60; and the apogee H falls in P. 4. l. 15 of Cancer [4 degrees, 15 minutes of ☊]. From the other inference, however — where the ratio is taken at the middle of Leo — the apogee comes out as P. 4. l. 19 of Cancer [4 degrees, 19 minutes of ☊], and the eccentricity Z E is P. 2. l. 7. //. 44 [2 degrees, 7 minutes, 44 seconds], in the units in which the semidiameter of the eccentric is taken as 60. This is what we set ourselves to find.

Now that the Sun's apogee and eccentricity for the hundredth year now elapsed have been found in this way, we shall learn the Sun's simple motion about each equinox, and we shall compare it with our own observations and with the numbers deduced from them, so that a fixed and uniform measure of the Sun's course from the beginning of the zodiac [a initio Dodecatemorii — the first of the twelve signs, i.e. Aries] may be laid down for these centuries.

First, then, I shall apply it to the vernal equinox of the year 1488, which at Nuremberg — according to the chord-distances of the Sun from the vertex recorded by the often-mentioned Bernhard Walther — I find, on careful examination, to have occurred on March, D. 10. H. 15. l. 40 P.M. [the 10th day, 15 hours, 40 minutes]. On our own meridian it was D. 10. H. 15. l. 55 [the 10th day, 15 hours, 55 minutes], for we lie about a quarter of an hour of time to the east of Nuremberg. At that time the Sun was, in its true and apparent position, at the very beginning of Aries; but according to the uniformity of its mean course it was P. 2. l. 1. //. 35 [2 degrees, 1 minute, 35 seconds] further forward. For so great is the Sun's prosthaphaeresis [Prosthaphaeresis — the equation of center] at the vernal equinox, as is plain from the figure here added, in which the angle B C D is P. 94. l. 15 [94 degrees, 15 minutes]: through the distance of the beginning of Aries from the true place of the Sun at the apogee, found earlier at 4 degrees 5 minutes [?] of Cancer, it is known; and D C, the eccentricity, was found to be 35481, in the

units in which D B is 1000000. Hence the angle D B C is given as P. 2. M. 1. s. 35 [2 degrees, 1 minute, 35 seconds] (as I said), and this is subtractive,

Diagram. A single circle in the lower right corner of the page illustrating the prosthaphaeresis construction at the vernal equinox. Points around and within the circle:

- A (top): point on the rim
- B (right): point on the rim
- D (interior, upper, left of center): interior point joined by chords to A and B
- C (center / just left of center): center point
- E (bottom): point on the rim Chords connect A to D, D to B, and the vertical diameter runs A–C–E.

since the true motion lies further along than the mean. The Sun's simple position at that time was therefore Sig. 11. G. 58. l. 25 [sign 11, 58 degrees (?) (recte: 28 degrees), 25 minutes].

Now let us attempt the same for the year 1588 as it draws to a close, by the same inductive reasoning. For this year, from my own and equally accurate observations, I found that the Sun entered the point of the vernal equinox on March, the 9th day, H. 20. l. 45 P.M. [20 hours, 45 minutes]. The prosthaphaeresis, however, is subtractive, in accordance with the apogee and eccentricity established by us for this year at P. 2. l. 2. // 35 [2 degrees, 2 minutes, 35 seconds]; for in the preceding configuration the angle D C B is here P. 95. l. 30 [95 degrees, 30 minutes], and the side D C is 35840, in the units in which D B is 1000000. Hence the angle D C B comes out — measuring the prosthaphaeresis, as I said, and consequently — so that, if we subtract it from the Sun's true place set at the very entry into Aries, the Sun's simple position for the given time will result as Sig. 11. P. 27. l. 57. // 25 [sign 11, 27 degrees, 57 minutes, 25 seconds].

In our observation, then, exactly one scruple [scrupulum — one minute] is wanting — namely, that the Sun crosses the midpoint of its course within 25 minutes (?) of time at the nearest (for in the hourly progress the Sun's simple motion is not sufficiently exact, nor can it lie hidden in the year-magnitude and daily motion assumed earlier). Therefore, if we add 25 minutes of an hour to our equinox, the time will come out as H. 21. l. 10 [21 hours, 10 minutes] — the time at which the Sun, by its simple course, after completing 100 revolutions, returns to the same position it held at the time of Walther's observation. There have therefore elapsed, on account of the Julian year's excess over the celestial one, in a hundred mean revolutions of the Sun, H. 18. l. 45 [18 hours, 45 minutes]. Thus,

in each circuit, the magnitude of the year as assumed from Julius falls short, D. 365. H. 6, by l. 11. // 15 [11 minutes, 15 seconds]. There emerges, therefore, the true magnitude of the mundane year, with respect to the vernal equinox, derived from this Waltherian observation over the 100 elapsed years and compared with our own, in the following way.

The True Length of the Celestial Year for the Coming Centuries, Derived with Respect to the Equinoxes

D.	H.	'.	".
365	5	48	45

We shall confirm the same result using, in addition, the autumnal equinoxes observed at both epochs. From Walther's [Bernhard Walther] observations of 1488, the equinox near the beginning of Libra ($\simeq$) is found, from chords measured from the vertex, to have fallen on 13 September at 9h 20'. This was established especially by comparing several of the antecedent and subsequent years' reversals [Adversiones], examining them carefully against one another, and adjusting them suitably where needed (just as we also took diligent care over the vernal equinox). But that moment lay a quarter of an hour later relative to our own location, so it falls on 9h 35' of the stated day. Our own autumnal equinox in the year 1588 occurred on 12 September at 15h 15' (as was also shown above).

The simple motion for the two epochs will work out as follows. Since the prosthaphaeresis of the Sun ($\odot$) near the beginning of Libra ($\simeq$) is the same as it earlier was at the start of Aries (Υ) — for in both cases the Sun is equally removed, here from apogee, there from perigee — that prosthaphaeresis will be, according to the apogee and eccentricity of the year 1488, likewise 2 parts, 1 minute, 35 seconds [part. 2. min. 1. sec. 35]. For this year 1588, however, the same value is 2 parts, 2', 35" [P. 2. '. 2. ". 35], so that — no less than before — it is clear from the accompanying figure, where the angle D C B is the distance from Walther's apogee, 85 parts, 1' 45" [P. 85, ' 45], and D C is the eccentricity, 35481 in units where B D is 1,000,000. But our own [distance] from the same apogee is 84 parts,

Diagram. A circle (the eccentric) with a vertical diameter running from A at the top through the interior to E at the bottom. Point B lies on the circumference at the left; from B two chords are drawn inward toward points D and C, which sit close together on the vertical diameter slightly below the center. The figure

illustrates the angle D C B (the distance from apogee) together with the eccentricity D C against the radius B D.

- A (top of circle): apogee end of the vertical diameter
- E (bottom of circle): perigee end of the vertical diameter
- B (left, on circumference): vertex from which the two chords are drawn
- D (interior, on vertical diameter, just below center): endpoint of the chord defining the eccentricity D C
- C (interior, on vertical diameter, just below D): center / endpoint defining eccentricity D C

1' 30" [. 30 — completing "84 parts, 1' 30"" from the previous page] and the eccentricity 35840. It therefore turns out that in both cases the angle D B C, as has been indicated, is similar to the earlier one derived near the vernal equinox. This prosthaphaeresis, moreover, is additive, because the mean motion of the Sun (☉) — which is what we aim to know — follows the true and apparent motion. Accordingly, at the time of the vernal equinox in the aforesaid year 1488, the simple [position of the] Sun (☉) was Sign 6, 2 parts, 1' 1" 35"" [Sig. 6. P. 2. ' 1. " . 35]; while in this year 1588, at the same autumnal equinox at the time indicated above, the same value comes out by similar reasoning as Sign 6, 2 parts, 1' 2" 35"" [Sig. 6. P. 2. ' 2. " . 35], exceeding the other by a single first scruple [minute].

Since these values agree so neatly with one another, there is no doubt that the annual quantity has been correctly fixed by us for the coming centuries; and from this it likewise follows together that both sets of observations — Walther's as much as our own — and the orderings of the apogees and eccentricities are correctly established.

This calculated quantity of the equinoctial year, even though it has not been derived from the longest spans of centuries (which in itself would have been more satisfactory, and would seem to earn a more exact and indubitable testimony in the smallest parts) — nevertheless we are confident that it is sufficiently certain and settled for the course of some hundreds of years. We judge it safer to derive it from the interposition of at least one hundred years, through observations closely scrutinized and in times least open to doubt, than to seek this limit from the longest intervals of centuries, through less reliable observations and a dubious fixing of times. This is especially so since our intention is only to adapt the particular restitution of the solar motion to these present centuries. Moreover, if we had drawn the whole matter here from more remote observations, the unequal anticipation of the equinoxes would have been

too great an impediment to us, both for the uniform reckoning of the year and also for adapting the simple solar course to these times.

Therefore, content with this constitution of the mundane or equinoctial year as sufficiently exact for these centuries, we shall set in order the simple motions of the Sun (☉) appropriate to this measurement. This is very easily done. For if we distribute the magnitude of the year now found across a whole circle, the simple [motion] of the Sun for a single day comes out as:

P.	′.	″.	‴.	″″.	v.	v′.	v″.
0	59	8	19	49	51	40	14

From this, afterwards, with very little labor, all the remaining equal motions — annual, monthly, and daily, and therefore also hourly — are derived. As for how matters stand with respect to the annual courses, they are as follows:

			s P						
			°	′	″	‴	″″	″″″	″″″″
Simple motion of the Sun in years	in a year	common	1	2	45	40	38	15	
			1	9					
	in years	bissextile	0	0	44	48	58	5	
		20	0	0	9	14	24	14	
		100	0	0	46	12	1	11	
		500	0	3	51	0	5	56	

Following this same scheme and the proportionality of the motions, we have compiled the tables of equal motions, so that the epoch is set up from the year 1400 up to 1800 through 400 intermediate [years], and in addition I have noted the simple motion at each successive 20 years for certain summary purposes (a leap being made, that is, by twenty-year steps, so that the canon should not grow too large), with the months and days added, together with their scruples of motion in equal measure. The places of the apogee, however, I have assigned only to the years themselves, on account of the slowness of its motion, and that too in accordance with the uniformity of advance which is derived from Walther's [Bernhard Walther] observation up to the present — namely, so that the apogee advances 45 scruples of seconds for each single year. For even if some inequality may underlie this, it is nevertheless of almost no consequence within these four hundred years, and will not perceptibly alter the apparent motion of the Sun.

The epoch for noon on 1 January, however — to which we have arranged the rest before and after — can easily be established from the mean motion of the Sun (☉), which at the vernal equinox observed by us on 9 March, at 20h $\frac{3}{4}$, was Sign 11, 27 parts, 57' 25" [S. 11. P. 27. ' 57. " 25], as was shown before. For from the noon of the January immediately preceding, in the assumed bissextile year, up to this moment of the vernal equinox, there have elapsed 68 days, 20 hours, 45 minutes, in which the Sun completes, by mean motion, according to the proportion of the daily course indicated above, [the amount] Sign 2, 7 parts, 52' 35" [S. 2. P. 7. ' 52. " 35]. If this is subtracted from the simple [position of the] Sun (☉), which it had at the said equinox, the same equal [motion] of the Sun for the Calends of January comes out as Sign 9, 20 parts, 4' 50" [S. 9. P. 20. ' 4. " 50]. And from this point, if it is subtracted in the antecedent years and added in the subsequent ones, the simple annual motion proceeding in order — as far as one wishes to go — the equal radix of the Sun for any years whatever will not be unknown. This caution must, however, be observed: that in every fourth year, which is intercalary, the number proper not to a common but to a bissextile year be added, or likewise subtracted.

With the equal motions premised in this way, we shall, through the following table of prosthaphaereses, call the inequality that affects each individual degree of distance from apogee, diligently computed according to our eccentricity, "for the correction" [sub emendationem]. Afterwards we shall make known the alteration of the daily motion at those same distances from apogee, so that the computation of the solar ephemerides from these tables may be easier. We shall also add an example of these tables for the two years in which the New Star (with which this Book is concerned) appeared, so that if at any time the solar course is required here — whether from our own observations or from others' — directed to this Star, it may at once be ready to hand; and so that it may be plain to the eye at a single glance how far the calculation, both Alphonsine [Alphonsinus] and Copernican [Copernicus], departs from the celestial standard. And all these things will shortly be contained, with their due arrangement, in the following tables.

Epochs of the Mean Motions of the Sun

EPOCHS OF THE MEAN MOTIONS OF THE SUN [EPOCHAE MEDIORUM MOTUUM SOLIS]

The radices below give, for each year, the position of the solar apogee [Apogaei] and the mean longitude [Longitudinis], each expressed in signs (S.), degrees (P., *partes*), minutes ('), and seconds (").

For Collected Years [In Annis Collectis] (left column, 1400–1540)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1400	3	3	9	45	9	19	22	47
1420	3	3	24	45	9	19	32	2
1440	3	3	39	45	9	19	41	16
1460	3	3	54	45	9	19	50	31
1480	3	4	9	45	9	19	59	45
1500	3	4	24	45	9	20	9	0
1520	3	4	39	45	9	20	18	14
1540	3	4	54	45	9	20	27	28

For Expanded Years [In Annis Expansis] (left column, 1560–1585)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1560	3	5	9	45	9	20	36	43
1561	3	5	10	30	9	20	22	23
1562	3	5	11	15	9	20	8	4
1563	3	5	12	0	9	19	53	45
1564	3	5	12	45	9	20	38	34
1565	3	5	13	30	9	20	24	14
1566	3	5	14	15	9	20	9	55
1567	3	5	15	0	9	19	55	36
1568	3	5	15	45	9	20	40	25
1569	3	5	16	30	9	20	26	5
1570	3	5	17	15	9	20	11	46
1571	3	5	18	0	9	19	57	26

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1572	3	5	18	45	9	20	42	15
1573	3	5	19	30	9	20	27	56
1574	3	5	20	15	9	20	13	37
1575	3	5	21	0	9	19	59	17
1576	3	5	21	45	9	20	44	6
1577	3	5	22	30	9	20	29	47
1578	3	5	23	15	9	20	15	28
1579	3	5	24	0	9	20	1	8
1580	3	5	24	45	9	20	45	57
1581	3	5	25	30	9	20	31	38
1582	3	5	26	15	9	20	17	18
1583	3	5	27	0	9	20	2	59
1584	3	5	27	45	9	20	47	48
1585	3	5	28	30	9	20	33	29

For Expanded Years [In Annis Expansis] (right column, 1586–1619)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1586	3	5	29	15	9	20	19	9
1587	3	5	30	0	9	20	4	50
1588	3	5	30	45	9	20	49	39
1589	3	5	31	30	9	20	35	20
1590	3	5	32	15	9	20	21	0
1591	3	5	33	0	9	20	6	41
1592	3	5	33	45	9	20	51	30
1593	3	5	34	30	9	20	37	10
1594	3	5	35	15	9	20	22	51
1595	3	5	36	0	9	20	8	32
1596	3	5	36	45	9	20	53	21
1597	3	5	37	30	9	20	39	1
1598	3	5	38	15	9	20	24	42
1599	3	5	39	0	9	20	10	23

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1600	3	5	39	45	9	20	55	12
1601	3	5	40	30	9	20	40	52
1602	3	5	41	15	9	20	26	33
1603	3	5	42	0	9	20	12	14
1604	3	5	42	45	9	20	57	2
1605	3	5	43	30	9	20	42	43
1606	3	5	44	15	9	20	28	24
1607	3	5	45	0	9	20	14	4
1608	3	5	45	45	9	20	58	53
1609	3	5	46	30	9	20	44	34
1610	3	5	47	15	9	20	30	15
1611	3	5	48	0	9	20	15	55
1612	3	5	48	45	9	21	0	44
1613	3	5	49	30	9	20	46	25
1614	3	5	50	15	9	20	32	6
1615	3	5	51	0	9	20	17	46
1616	3	5	51	45	9	21	2	15
1617	3	5	52	30	9	20	48	16
1618	3	5	53	15	9	20	33	56
1619	3	5	54	0	9	20	19	37

EPOCHS OF THE MEAN MOTIONS OF THE SUN [EPOCHAE MEDIORUM MOTUUM SOLIS] (continued)

For Expanded Years [In Annis Expansis] (left column, 1620–1655)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1620	3	5	54	45	9	21	4	26
1621	3	5	55	30	9	20	50	7
1622	3	5	56	15	9	20	35	47
1623	3	5	57	0	9	20	21	28
1624	3	5	57	45	9	21	6	17
1625	3	5	58	30	9	20	51	58

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1626	3	5	59	15	9	20	37	38
1627	3	6	0	0	9	20	23	19
1628	3	6	0	45	9	21	8	8
1629	3	6	1	30	9	20	53	48
1630	3	6	2	15	9	20	39	29
1631	3	6	3	0	9	20	25	10
1632	3	6	3	45	9	21	9	59
1633	3	6	4	30	9	20	55	39
1634	3	6	5	15	9	20	41	20
1635	3	6	6	0	9	20	27	0
1636	3	6	6	45	9	21	11	50
1637	3	6	7	30	9	20	57	30
1638	3	6	8	15	9	20	43	11
1639	3	6	9	0	9	20	28	51
1640	3	6	9	45	9	21	13	40
1641	3	6	10	30	9	20	59	21
1642	3	6	11	15	9	20	45	2
1643	3	6	12	0	9	20	30	42
1644	3	6	12	45	9	21	15	31
1645	3	6	13	30	9	21	1	12
1646	3	6	14	15	9	20	46	53
1647	3	6	15	0	9	20	32	33
1648	3	6	15	45	9	21	17	22
1649	3	6	16	30	9	21	3	3
1650	3	6	17	15	9	20	48	43
1651	3	6	18	0	9	20	34	24
1652	3	6	18	45	9	21	19	13
1653	3	6	19	30	9	21	4	54
1654	3	6	20	15	9	20	50	34
1655	3	6	21	0	9	20	36	15

For Expanded Years [In Annis Expansis] (right column, 1656–1660)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1656	3	6	21	45	9	21	21	4
1657	3	6	22	30	9	21	6	45
1658	3	6	23	15	9	20	52	25
1659	3	6	24	0	9	20	38	6
1660	3	6	24	45	9	21	22	55

For Collected Years [In Annis Collectis] (right column, 1680–1800)

Year	Apogee S.	P.	'	"	Long. S.	P.	'	"
1680	3	6	39	45	9	21	32	9
1700	3	6	54	45	9	21	41	24
1720	3	7	9	45	9	21	50	38
1740	3	7	24	45	9	21	59	53
1760	3	7	39	45	9	22	9	7
1780	3	7	54	45	9	22	18	21
1800	3	8	9	45	9	22	27	36

Mean Motions in Individual Years up to 20 [Medii Motus in Annis Singulis usque ad 20]

Year no.	Apogee S.	P.	'	"	Long. S.	P.	'	"
1	0	0	0	45	11	2	45	41
						9		
2	0	0	1	30	11	2	31	21
						9		
3	0	0	2	15	11	2	17	2
						9		
4	0	0	3	0	0	0	1	51
5	0	0	3	45	11	2	47	32
						9		
6	0	0	4	30	11	2	33	12
						9		
7	0	0	5	15	11	2	18	53
						9		

Year no.	Apogee S.	P.	'	"	Long. S.	P.	'	"
8	0	0	6	0	0	0	3	42
9	0	0	6	45	11	2	49	22
10	0	0	7	30	11	2	35	3
11	0	0	8	15	11	2	20	44
12	0	0	9	0	0	0	5	33
13	0	0	9	45	11	2	51	13
14	0	0	10	30	11	2	36	54
15	0	0	11	15	11	2	22	35
16	0	0	12	0	0	0	7	24
17	0	0	12	45	11	2	53	4
18	0	0	13	30	11	2	38	45
19	0	0	14	15	11	2	24	26
20	0	0	15	0	0	0	9	14

EQUAL MOTION OF THE LONGITUDE OF THE SUN [AEQUALIS MOTUS LONGITUDINIS SOLIS]

Four sub-tables give the equal (mean) motion of the solar longitude accumulated over months, days, hours, and minutes respectively. Each entry is in signs (S.), degrees (G., *gradus*), minutes ('), and seconds (") as appropriate to its scale.

In Months [In Mensibus] — Common Year [Anni Communis]

Month	S.	G.	'	"
January [Ianuarius]	1	0	33	18
February [Februarius]	1	28	9	11
March [Martius]	2	28	42	30

Month	S.	G.	'	"
April [Aprilis]	3	28	16	39
May [Maius]	4	28	49	53
June [Iunius]	5	28	24	7
July [Iulius]	6	28	57	26
August [Augustus]	7	29	30	44
September	8	29	4	54
October [October]	9	29	38	12
November [Nouember]	10	29	12	22
December	11	29	45	40

In Months [In Mensibus] — Leap Year [Anni Bisextilis]

Month	S.	G.	'	"
January [Ianuarius]	1	0	33	18
February [Februarius]	1	29	8	20
March [Martius]	2	29	41	38
April [Aprilis]	3	29	15	48
May [Maius]	4	29	49	6
June [Iunius]	5	29	23	16
July [Iulius]	6	29	56	34
August [Augustus]	8	0	29	53
September	9	0	4	3
October [October]	10	0	37	21
November [Nouember]	11	0	11	31
December	0	0	44	49

In Days [In Diebus]

D.	G.	' (M.)	" (S.)
1	0	59	8
2	1	58	17
3	2	57	25
4	3	56	33

D.	G.	' (M.)	" (S.)
5	4	55	42
6	5	54	50
7	6	53	58
8	7	53	7
9	8	52	15
10	9	51	23
11	10	50	32
12	11	49	40
13	12	48	48
14	13	47	57
15	14	47	5
16	15	46	13
17	16	45	21
18	17	44	30
19	18	43	38
20	19	42	47
21	20	41	55
22	21	41	3
23	22	40	12
24	23	39	20
25	24	38	28
26	25	37	37
27	26	36	45
28	27	35	53
29	28	35	1
30	29	34	10
31	30	33	18

In Hours [In Horis]

H.	' (M.)	" (S.)
1	2	28

H.	' (M.)	" (S.)
2	4	56
3	7	24
4	9	51
5	12	19
6	14	47
7	17	15
8	19	34
9	22	11
10	24	38
11	27	6
12	29	34
13	32	2
14	34	30
15	36	58
16	39	26
17	41	53
18	44	21
19	46	49
20	49	17
21	51	45
22	54	13
23	56	40
24	59	8

In Minutes [In Minutis]

The minutes sub-table is printed in two paired blocks. The first covers minute-arguments 0–30; the second, 30–60. Each gives ' (M.) and " (S.) of accumulated motion.

M.	' (M.)	" (S.)	M.	' (M.)	" (S.)
0	0	0	30	1	14
1	0	2	31	1	16

M.	' (M.)	" (S.)	M.	' (M.)	" (S.)
2	0	5	32	1	19
3	0	7	33	1	21
4	0	10	34	1	24
5	0	12	35	1	26
6	0	15	36	1	29
7	0	17	37	1	31
8	0	20	38	1	34
9	0	22	39	1	36
10	0	25	40	1	39
11	0	27	41	1	41
12	0	30	42	1	43
13	0	32	43	1	46
14	0	34	44	1	48
15	0	37	45	1	51
16	0	39	46	1	53
17	0	42	47	1	56
18	0	44	48	1	58
19	0	47	49	2	1
20	0	49	50	2	3
21	0	52	51	2	6
22	0	54	52	2	8
23	0	57	53	2	11
24	0	59	54	2	13
25	1	2	55	2	15
26	1	4	56	2	18
27	1	7	57	2	20
28	1	9	58	2	23
29	1	11	59	2	25
30	1	14	60	2	28

TABLE OF SOLAR PROSTHAPHAERESES [TABULA PROSTHAPHAERESIIUM SOLARIUM]

Presupposing an eccentricity [eccentricitatem] of 3584, or P. 2 ' 9 [aut P. 2 ' 9].

This is the solar prosthaphaeresis [prosthaphaeresis] (equation of center) table. The two outer columns of degrees (G., *gradus*) of the argument run 0→30 (left) and 30→0 (right); the body holds three argument-blocks (headed **0**, **1**, **2** signs). For each block there is a "Subt:" sub-column of the prosthaphaeresis itself (P. ' ") and an interleaved "Diff: A." sub-column (' ") giving the tabular difference between successive entries. The differences are engraved staggered on the half-lines between the value-rows, as is standard for an interpolation table; below I align each difference to the value-row immediately above it. The footers read "11 Adde / 10 Adde / 9 Adde" with "Diff: S." beneath the difference columns.

Argument block 0 signs

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
0	0	0	0	2	5	30
1	0	2	5	2	5	29
2	0	4	10	2	4	28
3	0	6	14	2	4	27
4	0	8	18	2	4	26
5	0	10	22	2	4	25
6	0	12	26	2	4	24
7	0	14	30	2	4	23
8	0	16	33	2	3	22
9	0	18	36	2	3	21
10	0	20	39	2	3	20
11	0	22	41	2	2	19
12	0	24	43	2	2	18
13	0	26	45	2	2	17
14	0	28	47	2	2	16
15	0	30	48	2	1	15
16	0	32	49	2	1	14
17	0	34	49	2	0	13

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
18	0	36	48	1	59	12
19	0	38	47	1	59	11
20	0	40	45	1	58	10
21	0	42	43	1	58	9
22	0	44	40	1	57	8
23	0	46	36	1	56	7
24	0	48	31	1	55	6
25	0	50	25	1	54	5
26	0	52	18	1	53	4
27	0	54	11	1	53	3
28	0	56	3	1	52	2
29	0	57	54	1	51	1
30	0	59	44	1	50	0

Footer: "11 Adde — Diff: S."

Argument block 1 sign

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
0	0	59	44	1	49	30
1	1	1	33	1	48	29
2	1	3	21	1	47	28
3	1	5	8	1	46	27
4	1	6	54	1	44	26
5	1	8	38	1	43	25
6	1	10	21	1	42	24
7	1	12	3	1	41	23
8	1	13	44	1	40	22
9	1	15	24	1	39	21
10	1	17	3	1	37	20
11	1	18	40	1	36	19
12	1	20	16	1	35	18
13	1	21	51	1	33	17

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
14	1	23	24	1	32	16
15	1	24	56	1	31	15
16	1	26	27	1	29	14
17	1	27	56	1	27	13
18	1	29	23	1	26	12
19	1	30	49	1	24	11
20	1	32	13	1	23	10
21	1	33	36	1	22	9
22	1	34	58	1	20	8
23	1	36	18	1	18	7
24	1	37	36	1	16	6
25	1	38	52	1	14	5
26	1	40	6	1	12	4
27	1	41	18	1	11	3
28	1	42	29	1	9	2
29	1	43	38	1	8	1
30	1	44	46	1	6	0

Footer: "10 Adde — Diff: S."

Argument block 2 signs

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
0	1	44	47	1	6	30
1	1	45	53	1	4	29
2	1	46	57	1	2	28
3	1	47	59	1	0	27
4	1	48	59	0	58	26
5	1	49	57	0	56	25
6	1	50	53	0	54	24
7	1	51	47	0	52	23
8	1	52	39	0	51	22
9	1	53	30	0	49	21

G. (left)	Subt: P.	'	"	Diff:A. '	Diff:A. "	G. (right)
10	1	54	19	0	48	20
11	1	55	7	0	45	19
12	1	55	52	0	42	18
13	1	56	34	0	40	17
14	1	57	14	0	38	16
15	1	57	52	0	36	15
16	1	58	28	0	34	14
17	1	59	2	0	32	13
18	1	59	34	0	30	12
19	2	0	4	0	28	11
20	2	0	32	0	26	10
21	2	0	58	0	24	9
22	2	1	22	0	21	8
23	2	1	43	0	19	7
24	2	2	2	0	17	6
25	2	2	19	0	14	5
26	2	2	33	0	12	4
27	2	2	45	0	10	3
28	2	2	55	0	8	2
29	2	3	3	0	6	1
30	2	3	9	—	—	0

Footer: "9 Adde — Diff: S."

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Solar Prosthaphaeresis Table (continued) — Page 61

This page carries the right-hand half of the **Table of Solar Prosthaphaereses** [**Tabula Prosthaphaeresium Solarium**], headed:

ADAPTED TO OUR TIMES [NOSTRIS TEMPORIBUS ACCOMMODATA].

Where the semidiameter of the eccentric [eccentrici] is 100,000, or P. 60 / 0.

The table is a symmetric, double-entry argument table. Each block carries an argument-degree column (G.), a value in periods/minutes/seconds (P. ' "), and a difference column (Diff.). The column-group headings at the top run with the **upper** argument (degrees 0 → 30 descending in the rightmost G. column from 30), and the headings at the **foot** of the page run with the value read in the opposite direction. The long-s glyph (l) is transcribed as the digit it represents.

Upper headings (read top-down): "3 Subt: | Diff:A.S." — "4 Sub: | Diff:S." — "5 Subt: | Diff:S." **Lower headings (read bottom-up, at foot):** "8 Adde | Diff:S.A." — "7 Adde | Diff:A." — "6 Adde | Diff:A."

The rightmost narrow column repeats the degree argument (G.) running 30 → 0.

Block "3 Subt." and adjoining "Diff:A.S."

G.	P.	'	"	Diff '	Diff "
0	2	3	9	0	4
1	2	3	13	0	2
2	2	3	15	[recte: ?]	2
3	2	3	13	0	4
4	2	3	9	0	6
5	2	3	3	0	8
6	2	2	55	0	10
7	2	2	45	0	12
8	2	2	33	0	14
9	2	2	19	0	17
10	2	2	2	0	19
11	2	1	43	0	21
12	2	1	22	0	24
13	2	0	58	0	26
14	2	0	32	0	28
15	2	0	4	0	30
16	1	59	34	0	32

G.	P.	'	"	Diff'	Diff''
17	1	59	2	0	35
18	1	58	27	0	37
19	1	57	50	0	39
20	1	57	11	0	41
21	1	56	30	0	44
22	1	55	46	0	46
23	1	55	0	0	48
24	1	54	12	0	51
25	1	53	21	0	53
26	1	52	28	0	55
27	1	51	33	0	57
28	1	50	36	0	59
29	1	49	37	1	1
30	1	48	36	—	—

Block "4 Sub." and adjoining "Diff:S."

G.	P.	'	"	Diff'	Diff''
0	1	48	36	1	3
1	1	47	33	1	5
2	1	46	28	1	7
3	1	45	21	1	9
4	1	44	12	1	11
5	1	43	1	1	14
6	1	41	47	1	16
7	1	40	31	1	17
8	1	39	14	1	19
9	1	37	55	1	20
10	1	36	35	1	22
11	1	35	13	1	24
12	1	33	49	1	26
13	1	32	23	1	29

G.	P.	'	"	Diff'	Diff''
14	1	30	54	1	31
15	1	29	23	1	33
16	1	27	50	1	34
17	1	26	16	1	36
18	1	24	40	1	37
19	1	23	3	1	38
20	1	21	25	1	39
21	1	19	46	1	41
22	1	18	5	1	43
23	1	16	22	1	46
24	1	14	36	1	48
25	1	12	48	1	49
26	1	10	59	1	50
27	1	9	9	1	51
28	1	7	18	1	52
29	1	5	36	1	53
30	1	3	33	—	—

Block "5 Subt." and adjoining "Diff:S." with rightmost G. column

G. (left)	P.	'	"	Diff'	Diff''	G. (right)
0	1	3	33	1	53	30
1	1	1	40	1	55	29
2	0	59	45	1	57	28
3	0	57	48	1	59	27
4	0	55	49	2	1	26
5	0	53	48	2	1	25
6	0	51	47	2	2	24
7	0	49	45	2	2	23
8	0	47	43	2	3	22
9	0	45	40	2	4	21
10	0	43	36	2	5	20

G. (left)	P.	'	"	Diff'	Diff"	G. (right)
11	0	41	31	2	6	19
12	0	39	25	2	7	18
13	0	37	18	2	8	17
14	0	35	10	2	9	16
15	0	33	1	2	9	15
16	0	30	52	2	10	14
17	0	28	42	2	10	13
18	0	26	32	2	11	12
19	0	24	21	2	11	11
20	0	22	10	2	11	10
21	0	19	59	2	12	9
22	0	17	47	2	12	8
23	0	15	35	2	13	7
24	0	13	22	2	13	6
25	0	11	9	2	13	5
26	0	8	56	2	14	4
27	0	6	42	2	14	3
28	0	4	28	2	14	2
29	0	2	14	2	14	1
30	0	0	0	—	—	0

Table of the Sun's Daily Motion — Page 62

**TABLE OF THE SUN'S DAILY MOTION FOR EACH DEGREE OF
DISTANCE FROM THE APOGEE [TABULA MOTUS DIURNI SOLIS AD
SINGULOS GRADUS DISTANTIAE AB APOGAE0].**

Three side-by-side panels, each with: distance from apogee (Dist. ab Apog., G.) | the Sun's daily motion (Diurnus Solis, ' ") | distance from apogee (Dist. ab Apog., G.). The rightmost "Dist. ab Apog." column runs the complementary count (360 down to 270).

Panel 1 (G. 0–30)

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
0	57	5	360
1	57	5	359
2	57	6	358
3	57	6	357
4	57	6	356
5	57	6	355
6	57	7	354
7	57	7	353
8	57	7	352
9	57	7	351
10	57	8	350
11	57	8	349
12	57	8	348
13	57	9	347
14	57	9	346
15	57	10	345
16	57	10	344
17	57	11	343
18	57	11	342
19	57	12	341
20	57	12	340
21	57	13	339
22	57	14	338
23	57	15	337
24	57	16	336
25	57	16	335
26	57	17	334
27	57	18	333
28	57	19	332
29	57	20	331

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
30	57	21	330

Panel 2 (G. 30–60)

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
30	57	21	330
31	57	23	329
32	57	24	328
33	57	25	327
34	57	26	326
35	57	28	325
36	57	29	324
37	57	30	323
38	57	31	322
39	57	32	321
40	57	33	320
41	57	35	319
42	57	36	318
43	57	37	317
44	57	39	316
45	57	40	315
46	57	42	314
47	57	43	313
48	57	45	312
49	57	46	311
50	57	48	310
51	57	50	309
52	57	51	308
53	57	53	307
54	57	55	306
55	57	57	305
56	57	59	304

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
57	58	0	303
58	58	2	302
59	58	4	301
60	58	6	300

Panel 3 (G. 60–90)

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
60	58	6	300
61	58	8	299
62	58	10	298
63	58	12	297
64	58	13	295
65	58	15	295
66	58	17	294
67	58	19	293
68	58	21	292
69	58	23	291
70	58	26	290
71	58	28	289
72	58	30	288
73	58	32	287
74	58	35	286
75	58	37	285
76	58	39	284
77	58	41	283
78	58	43	282
79	58	45	281
80	58	48	280
81	58	50	279
82	58	52	278
83	58	54	277

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
84	58	55	276
85	58	57	275
86	58	59	274
87	59	1	273
88	59	3	272
89	59	5	271
90	59	7	270

Table of the Sun's Daily Motion (continued) — Page 63

**ADAPTED TO THE ECCENTRICITY OF THIS AGE [AD
ECCENTRICITATEM HUIUS AEVI], WHICH IS P. 2 / 9 OF P. 60 / 0,
COMPOSED.**

The same three-panel structure, continuing the distance-from-apogee argument from 90 through 180.

Panel 1 (G. 90–120)

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
90	59	7	270
91	59	9	269
92	59	12	268
93	59	15	267
94	59	17	266
95	59	19	265
96	59	21	264
97	59	23	263
98	59	25	262
99	59	27	261
100	59	29	260
101	59	31	259
102	59	34	258
103	59	36	257
104	59	38	256

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
105	59	40	255
106	59	43	254
107	59	45	253
108	59	48	252
109	59	50	251
110	59	52	250
111	59	54	249
112	59	56	248
113	59	58	247
114	59	59	246
115	60	1	245
116	60	3	244
117	60	5	243
118	60	7	242
119	60	9	241
120	60	11	240

Panel 2 (G. 120–150)

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
120	60	11	240
121	60	13	239
122	60	15	238
123	60	17	237
124	60	18	236
125	60	20	235
126	60	22	234
127	60	24	233
128	60	26	232
129	60	28	231
130	60	30	230
131	60	32	229

Dist. ab Apog. G.	Diurnus '	Diurnus ''	Dist. ab Apog. G.
132	60	34	228
133	60	35	227
134	60	37	226
135	60	39	225
136	60	41	224
137	60	43	223
138	60	45	222
139	60	47	221
140	60	49	220
141	60	51	219
142	60	52	218
143	60	53	217
144	60	55	216
145	60	56	215
146	60	57	214
147	60	58	213
148	60	59	212
149	61	0	211
150	61	1	210

Panel 3 (G. 150–180)

Dist. ab Apog. G.	Diurnus '	Diurnus ''	Dist. ab Apog. G.
150	61	1	210
151	61	2	209
152	61	3	208
153	61	4	207
154	61	5	206
155	61	6	205
156	61	7	204
157	61	8	203
158	61	9	202

Dist. ab Apog. G.	Diurnus ′	Diurnus ″	Dist. ab Apog. G.
159	61	10	201
160	61	11	200
161	61	12	199
162	61	13	198
163	61	14	197
164	61	15	196
165	61	16	195
166	61	16	194
167	61	17	193
168	61	17	192
169	61	18	191
170	61	18	190
171	61	18	189
172	61	19	188
173	61	19	187
174	61	19	186
175	61	20	185
176	61	20	184
177	61	20	183
178	61	20	182
179	61	21	181
180	61	21	180

Ephemeris of the Sun for the Year 1572 — Page 64

EPHEMERIS OF THE SUN FOR THE YEAR 1572 [EPHEMERIS SOLIS AD ANNUM 1572].

Daily solar position (P. ′ ″ — sign-position, minutes, seconds) for each day (Dies, 1–31) across the first six months. In the "P." (position) column, sign-entry days show a zodiacal sign glyph instead of a degree number, marking the Sun's ingress into a new sign. The glyphs read: ♒ Aquarius (Jan 11), ♓ Pisces (Feb 9 region), ♈ Aries (Mar 10), ♉ Taurus (Apr 10), ♊ Gemini (May 11).

D i e s	J a n P.	J a n '	J a n "	F e b P.	F e b '	F e b "	M a r P.	M a r '	M a r "	A p r P.	A p r '	A p r "	M a i P.	M a i '	M a i "	Jun P.	Jun '	Jun "
1	20	30	0	22	0	38	21	5	18	21	37	15	20	39	36	20	18	7
2	21	31	16	23	1	15	22	4	57	22	35	47	21	37	15	21	15	16
3	22	32	31	24	1	50	23	4	33	23	34	17	22	34	53	22	12	25
4	23	33	45	25	2	23	24	4	7	24	32	45	23	32	29	23	9	33
5	24	34	58	26	2	54	25	3	38	25	31	11	24	30	3	24	6	40
6	25	36	10	27	3	23	26	3	7	26	29	34	25	27	36	25	3	48
7	26	37	21	28	3	50	27	2	34	27	27	54	26	25	8	26	0	55
8	27	38	30	29	4	15	28	1	59	28	26	13	27	22	39	26	58	2
9	28	39	49	✕	4	39	29	1	22	29	24	30	28	20	10	27	55	10
10	29	40	48	1	5	2	℣	0	43	♂	22	46	29	17	40	28	52	17
11	≈	41	55	2	5	22	1	0	2	1	21	1	Ⅱ	15	8	29	49	23
12	1	43	1	3	5	40	1	59	19	2	19	14	1	12	35	[rec te: 0]	46	39
13	2	44	6	4	5	56	2	58	34	3	17	25	2	10	1	1	43	35
14	3	45	10	5	6	10	3	57	46	4	15	34	3	7	25	2	40	41
15	4	46	14	6	6	23	4	56	56	5	13	40	4	4	38	3	37	46

D i s	Ja n P.	Ja n' P.	Ja n "	F e b P.	F e b' P.	F e b "	M a r P.	M a r' P.	M a r "	A p r P.	A p r' P.	A p r "	M a i P.	M a i' P.	M a i "	Jun P.	Jun n' P.	Jun n "
1 6	5	47	17	7	6	34	5	56	3	6	11	44	5	2	10	4	34	52
1 7	6	48	19	8	6	42	6	55	8	7	9	46	5	59	31	5	31	57
1 8	7	49	18	9	6	48	7	54	11	8	7	47	6	56	51	6	29	3
1 9	8	50	15	1 0	6	52	8	53	12	9	5	46	7	54	10	7	26	9
2 0	9	51	11	1 1	6	54	9	52	11	1 0	3	44	8	51	27	8	23	15
2 1 1	0	52	6	1 2	6	54	1 0	51	8	1 1	1	40	9	48	45	9	20	21
2 2	1	53	0	1 3	6	52	1 1	50	3	1 1	59	35	1 0	46	2	10	17	27
2 3	1	53	53	1 4	6	48	1 2	48	56	1 2	57	29	1 1	43	18	11	14	34
2 4	1	54	44	1 5	6	42	1 3	47	47	1 3	55	21	1 2	40	33	12	11	40
2 5	1	55	36	1 6	6	34	1 4	46	36	1 4	53	11	1 3	37	47	13	8	46
2 6	1	56	25	1 7	6	23	1 5	45	22	1 5	51	0	1 4	35	0	14	5	53
2 7	1	57	12	1 8	6	10	1 6	44	6	1 6	48	47	1 5	32	13	15	3	0
2 8	1	57	57	1 9	5	55	1 7	42	48	1 7	46	31	1 6	29	25	16	0	8
2 9	1	58	39	2 0	5	28	1 8	41	28	1 8	44	14	1 7	26	37	16	57	16
3 0	1	59	19	—	—	—	1 9	40	5	1 9	41	56	1 8	23	48	17	54	25

D	Ja			F	Fe			M	M			A	A			M	M	M	Ju		
i	Ja	Ja	Ja	e	Fe	Fe	Fe	a	M	M	M	p	A	A	A	M	M	M	Jun	Jun	Jun
s	P.	n'	"	P.	b'	"	"	P.	'	"	"	P.	'	"	"	P.	'	"	P.	n'	"
3	2	59	58	—	—	—		2	38	42	—	—	—			1	20	58	—	—	—
1								0								9					

Book I — Solar Restitution (continued)

Ephemeris of the Sun for the year 1572 — July to December (computed from these modern tables)

Running header: "DE NOVA STELLA ANNI 1572." Table caption: **EX HIS NEOTERICIS TABVLIS SVPPVTATA** ("Computed from these modern tables").
Daily solar longitude for the second half of 1572. Each month has three sub-columns: P° (degrees of the zodiac sign / sign), ' (minutes), " (seconds); within each month the degree column carries the running sign-ingress, marked by a zodiac glyph where a new sign begins. The day-of-month (Dies) column stands at the right.

D	Iuliu			Augus			Septe			Octobe			Nouembe			Decemb		
i	s	P°	' "	s	P°	' "	s	P°	' "	s	P°	' "	s	P°	' "	s	P°	' "
1	18		1 3 8				2 2 18			2 1 18			1 2 19			6 4 19		3 5
			5 3				9 9			9 6			1					5 5
2	19		4 4 19				2 8 19			2 4 19			0 5 20			6 4 20		3 1
			8 2				7			7 9			8			3		7 1
3	20		4 5 20				2 4 20			2 2 20			0 3 21			7 2 21		3 2
			5 1				4 8			6 5			8			4		8 7
4	21		4 1 21				2 3 21			2 2 21			0 2 22			8 7 22		3 4
			3				2 0			5			0					9 4
5	22		4 1 22				2 1 22			2 4 22			0 5 23			8 5 23		4 1
			0 2				0 4			3 1						2		1
6	23		3 2 23				1 5 23			2 2 22			5 5 24			9 3 24		4 1
			7 3				7 9			2 3			9 2			8		2 8
7	24		3 3 24				1 4 24			2 7 23			5 4 25			1 2 25		4 3

D i e s	Iuliu s P°	' "	Augus tus P°	' "	Septe mber P°	' "	Octobe r P°	' "	Nouembe r P°	' "	Decemb er P°	' "
		4 5		5 5		1		9 1		0 5		3 5
8	25	3 4	25	1 3	25	1 5	24	5 3	26	1 1	26	4 5
		1 8		3 2		9 3		9 3		1 4		4 4
9	26	2 1	26	1 2	26	1 4	25	5 2	27	1 5	27	4 1
		9		1 0		8 1		9 6		2		6 3
1	27	2 1	27	9 1	27	1 3	26	5 2	28	1 5	28	4 3
0		6 5		0		7 0		9 0		2 8		7 2
1	28	2 3	28	7 2	28	1 2	27	5 1	29	1 5	29	4 5
1		3 0				6 2		9 7		3 2		8 1
1	29	2 4	29	4 5	29	1 1	28	5 1	♄	1 4	♅	5 1
2		0 6		6		5 6		9 7	[Sagittari us]	4 7	[Capric orn]	0 1
1	♌	1 2	♍	2 5	♎	1 1	29	5 1	1	1 4	1	5 3
3	[Leo l]	8	[Virgo l]	2	[Libra]	4 3		9 9		5 4		1 1
1	1	1 1	1	0 5	1	1 1	♏	5 2	2	1 4	2	5 5
4		5 9		1		3 2	[Scorp io]	9 3		6 3		2 2
1	2	1 3	1	5 5	2	1 1	1	5 2	3	1 4	3	5 1
5		2 7		8 3		2 2		9 9		7 3		4 3
1	3	9 5	2	5 5	3	1 1	2	5 3	4	1 4	4	5 3
6		6		6 5		1 5		9 7		8 4		5 4
1	4	7 1	3	5 5	4	1 2	3	5 4	5	1 4	5	5 5
7		6		4 8		0 0		9 7		9 5		6 4
1	5	4 3	4	5 2	5	9 2	4	5 5	6	2 4	6	5 1
8		7		3		7		9 9		0 7		8 3
1	6	1 5	5	5 7	6	8 3	6	0 1	7	2 5	7	9 3
9		9		1		6		2		1 0		2
2	6	5 2	6	4 1	7	7 4	7	0 2	8	2 5	9	0 5
0		9 2		9 3		8		6		2 4		1
2	7	5 4	7	4 2	8	7 2	8	0 4	9	2 0	10	2 1
1		6 6		7 0				3		4		1

D i e s	Iuliu s P°	' "	Augus tus P°	' "	Septe mber P°	' "	Octobe r P°	' "	Nouembe r P°	' "	Decemb er P°	' "
2	8		5 1 8		4 3 9		6 1 9		1 2 10		2 7 11	3 3
2			4 1		5 1		9				5	1
2	9		5 3 9		4 4 10		5 3 10		1 2 11		2 1 12	4 5
3			1 8		3 5		7		4		6 6	0
2	10		4 6 10		4 1 11		4 5 11		1 4 12		2 2 13	6 1
4			9		2		7		9		7 6	0
2	11		4 3 11		4 2 12		4 2 12		2 1 13		2 3 14	7 2
5			6 5		0 0		0		6		8 7	9
2	12		4 5 12		3 4 13		3 4 13		2 4 14		2 4 15	8 4
6			4		8 2		5		3		9 8	7
2	13		4 3 13		3 4 14		3 1 14		3 1 15		3 0 16	1 5
7			1 6		7		2		2		1	0
2	14		3 8 14		3 2 15		2 4 15		3 4 16		3 1 17	1 2
8			9		5 7		1		2		2 2	1 2
2	15		3 4 15		3 5 16		2 1 16		4 1 17		3 2 18	1 3
9			6 1		3 1		2		5		3 5	2 9
3	16		3 1 16		3 1 17		1 4 17		4 4 18		3 3 19	1 5
0			4 5		2 7		6		9		4 9	3 5
3	17		3 5 17		3 4 —		—18		5 2		—20	1 1
1			1 1		0 5				5			5 1

Ephemeris of the Sun for the year 1573 — January to June

Running header: "TYCHONIS BRAHE LIB. I." Table caption: **EPHEMERIS SOLIS AD ANNVM 1573** ("Ephemeris of the Sun for the year 1573"). Daily solar longitude for the first half of 1573. Sub-columns P° / ' / " per month; the day-of-month (Dies) column stands at the left.

D
i

e s	Ianuarius P°	Februarius P°	Martius P°	Aprilis P°	Maius P°	Iunius P°	
1	21	1 2 22 6 2	4 3 20 6 2	5 4 21 0 8	2 4 20 3	2 3 20 5 8	4 2 0
2	22	1 3 23 7 7	4 8 21 7	5 2 22 0 6	2 3 21 1 6	2 1 21 3 7	1 2 9
3	23	1 5 24 8 1	4 4 22 7 1	5 2 23 0	2 6 22 0	2 5 21 0 5	5 3 8 8
4	24	2 4 25 0	4 1 23 8 2	4 3 24 9 6	1 3 23 8 4	1 3 22 8 2	5 4 5 6
5	25	2 1 26 1 6	4 4 24 8 1	4 9 25 9	1 0 24 7	1 8 23 6	5 5 2 4
6	26	2 2 27 2 7	4 9 25 9	4 4 26 8 0	1 2 25 5 4	1 4 24 3 3	5 1 0
7	27	2 3 28 3 8	4 3 26 9 6	4 9 27 8	1 4 26 3 6	1 1 25 1 6	4 8 7
8	28	2 4 29 4 8	5 2 27 0	4 3 28 7 5	1 6 27 2	8 4 26 8	4 1 4 5
9	29	2 5 ☿ 5 7 [Pisces] 50	2 —28 6	4 5 29 6 8	1 2 28 0 4	6 1 27 9	4 2 1 2
10	☿ [Aquarius] 27	5 —1	5 4 29 0 8	4 1 ☌ 6 9 [Taurus] 8	4 —29 0	3 4 28 9	3 2 8 9
11	1	2 1 2 8 2	5 8 ♈ 1 [Aries] 45	3 —1 3	6 5 ♊ 4 [Gemini] 1	1 —29 7	3 3 5 5
12	2	2 1 3 9 8	5 2 1 1 5	4 5 2 4 5	5 6 0	5 4 ☌ 8 3 [Cancer] 32	4 — 1
13	3	3 2 4 0 3	5 3 2 1 9	4 1 3 4 1	3 1 1 7	5 1 1 6 8	2 4 9 7
14	4	3 2 5 1 7	5 5 3 1 0	4 2 4 3 5	1 2 2 7	5 3 2 3 1	2 5 6 3

D							
i							
e	Ianuarius	Februarius	Martius	Aprilis	Maius	Iunius	
s	s P°	' " rius P°	' " s P°	' " p°	' " p°	' " p°	' "
1	5	3 2 6	5 5 4	4 3 4	5 3 3	5 5 3	2 5
5		2 9	1 7	2 6	9 6	0 5	3 9
1	6	3 3 7	5 6 5	4 4 5	5 4 4	4 1 4	2 4
6		3 0	2	1 3	7 0	8 7	1
1	7	3 3 8	5 1 6	4 4 6	5 4 5	4 3 5	1 9
7		4 0	2 3	0 8	5 2	5 9	8
1	8	3 2 9	5 1 7	3 5 7	5 4 6	4 0 6	1 1
8		5 9	2 8	9 1	3 3	3	5 5
1	9	3 2 10	5 2 8	3 5 8	5 4 7	4 2 7	1 2
9		6 6	2 0	8 2	1 2	0 0	2 1
2	10	3 2 11	5 2 9	3 5 9	4 4 8	3 3 8	9 2
0		7 1	2 0	7 1	9 0	7 9	6
2	11	3 1 12	5 1 10	3 4 10	4 3 9	3 5 9	6 3
1		8 5	2 8	6 9	7 6	4 6	2
2	12	3 7 13	5 1 11	3 4 11	4 3 10	3 1 10	3 3
2		9	2 4	5 5	5 2	2 2	8
2	13	3 5 14	5 9 12	3 3 12	4 2 11	2 2 11	0 4
3		9 8	2	4 9	3 7	9 8	4
2	14	4 4 15	2 2 13	3 3 13	4 2 12	2 4 11	5 5
4		0 8		3 1	1 0	6 3	7 1
2	15	4 3 16	5 5 14	3 2 14	3 1 13	2 5 12	5 5
5		1 7	1 2	2 1	9 2	3 7	4 7
2	16	4 2 17	5 3 15	3 7 15	3 1 14	2 1 13	5 4
6		2 5	1 9	1	7	1 2	2
2	17	4 1 18	5 2 16	2 5 16	3 4 15	1 2 14	4 1
7		3 1	1 4	9 1	4 9	8 5	9 1
2	18	4 5 9	5 7 17	2 3 17	3 3 16	1 3 15	4 1
8		3 5 [recte: 19]	1	8 3	2 4	5 8	6 9
2	19	4 3 —	—18	2 1 18	3 1 17	1 5 16	4 2
9		4 7		7 3	0 7	2 0	3 7
3	✠	4 1 —	—19	2 5 19	2 5 18	1 1 17	4 3

D							
i							
e	Ianuarius	Februarius	Martius	Aprilis	Maius	Iunius	
s	s P°	' " rius P°	' " s P°	' " P°	' " P°	' " P°	' "
0	[Pisces?]	5 7		5 8	7 8	0	0 5
2							
3	21	4 5 —	—20	2 3 —	—19	7 1 —	—
1		5 5		4 6		1	

Ephemeris of the Sun for the year 1572 — July to December (second computed table)

Running header: "DE NOVA STELLA ANNI 1572." Table caption: **EX HIS NEOTERICIS TABVLIS SVPPVTATA** ("Computed from these modern tables"). A second daily-longitude table for the second half of 1572, set out as on p. 65 but carrying the comparison values. Sub-columns P° / ' / " per month; the day-of-month (Dies) column stands at the right.

D							
i							
e	Iuliu	Augus	Septe	Octobe	Nouembe	Decemb	
s	s P°	' " tus P°	' " P°	' " r P°	' " r P°	' " er P°	' "
1	18	3 4 18	1 3 18	1 4 17	4 5 18	5 1 19	2 5
		7 4	5 1	5	6 2	1 6	0 7
2	19	3 5 19	1 8 19	1 3 18	4 2 19	5 5 20	2 1
		4 3	3	3 6	6 9	1 4	2 3
3	20	3 2 20	1 4 20	1 1 19	4 8 20	5 3 21	2 2
		2	0 8	2 1	6	2 4	3 9
4	21	2 1 21	8 3 21	1 4 20	4 4 21	5 1 22	2 4
		9 2	0	0 8	5 9	3 6	4 6
5	22	2 2 22	6 1 22	9 2 21	4 3 22	5 0 23	2 3
		6 3	3	7	5 3	4	6
6	23	2 3 23	3 5 23	8 8 22	4 1 23	5 4 24	2 2
		3 4	8		5 9	4 7	7 0
7	24	2 4 24	1 4 24	6 5 23	4 7 24	5 3 25	2 3
		0 6	4	2	5	5 6	8 8
8	25	1 5 24	5 3 25	5 3 24	4 5 25	5 2 26	2 5

D i e s	Iuliu s P°	' "	Augus tus P°	' "	Septe mber P°	' "	Octobe r P°	' "	Nouembe r P°	' "	Decemb er P°	' "
		7 9		9 1		8		4 7		6 6		9 6
9	26	1 1	25	5 1	26	4 2	25	4 4	26	5 1	27	3 1
		5 2		7 9		6		4 9		7 7		1 4
1	27	1 2	25	5 8	27	3 1	26	4 4	27	5 1	28	3 3
0		2 6		5		5		4 3		8 0		2 3
1	28	9 4	27	5 5	28	2 6	27	4 4	28	5 4	29	3 5
1		1		2 8				4 0		9		3 2
1	29	6 5	23	5 5	29	0 5	28	4 4	29	5 5	♊	3 1
2		7		0 1		9		4 0		9 9	[Capric orn]	5 2
1	♌ [Leo]	4 1	29	4 4	29	5 5	29	4 4	♐	0 5	1	3 3
3		3		8 7		9 5		4 2	[Sagittari us]	5		6 2
1	1	1 2	♍ [Virgo]	4 4	♎ [Libra]	5 5	♏ [Scorp io]	4 4	2	1 5	2	3 5
4		9		6 6		8 3		4 6		2		7 2
1	1	5 4	1	4 4	1	2 5	1	4 5	3	2 5	3	3 1
5		8 6		4 8		7 3		4 0		1		9 3
1	2	5 5	2	4 5	2	5 5	2	4 5	4	3 5	4	4 3
6		6		2 0		6 6		4 9		2		0 4
1	3	5 2	3	4 5	3	5 1	3	4 9	5	4 5	5	4 5
7		3 5		0 3		6		5		3		1 5
1	4	5 4	4	3 5	4	5 8	4	4 2	6	5 5	6	4 1
8		0 6		8 7		5		5 1		5		3 6
1	5	4 8	5	3 2	5	5 1	5	4 3	7	6 5	7	4 3
9		8		7		4 7		5 4		8		4 6
2	6	4 3	6	3 8	6	5 2	6	4 4	8	8 2	9	4 5
0		5 1		5		3 8		5 8				5 6
2	7	4 5	7	3 1	7	5 4	7	4 4	9	9 8	10	4 1
1		2 5		3 3		2 1		6				7 6
2	8	4 1	8	3 2	8	5 5	8	4 2	10	1 1	11	4 3
2		0 9		1 1		1 7		6 3		0 5		8 6

D i e s	Iuliu s P°	Augus tus P°	Septe mber P°	Octobe r P°	Nouembe r P°	Decemb er P°	
2	9	3 4 9	2 3 9	5 1 9	4 4 11	1 2 12	4 5
3		7 5	9 4	1 4	6 4	1 3	9 5
2	10	3 1 10	2 5 10	5 3 10	4 7 12	1 3 13	5 1
4		5 2	7 1	0 3	7	2 2	1 3
2	11	3 4 11	2 1 11	4 5 11	4 3 13	1 4 14	5 3
5		2 0	6 0	9 5	7 2	3 1	2 1
2	12	3 1 12	2 3 12	4 1 12	4 5 14	1 5 15	5 4
6		0 0	4 2	9 8	7 9	4 2	3 8
2	13	2 4 13	2 5 13	4 4 13	4 2 15	1 3 16	5 5
7		7 1	2 5	8 4	8 7	6	5
2	14	2 1 14	2 1 14	4 1 14	4 5 16	1 5 17	5 2
8		5 3	1 9	8 3	8 7	7	6 1
2	15	2 4 15	1 4 15	4 4 15	4 2 17	1 2 18	5 3
9		2 6	9 3	7 4	9 9	8 3	7 8
3	16	2 2 16	1 8 16	4 1 16	5 3 18	1 4 19	5 4
0		0 0	8	7 7	0	9 2	3 5
3	17	1 5 17	1 3 —	—17	5 3	—20	0 1
1		7 5	6 5		0 9		1

Closing of the solar argument; on the instruments required for this precision

Running header: "TYCHONIS BRAHE LIB. I." The ephemeris tables give way back to prose.

These matters concerning the Sun's course — both its uniform motion and its apparent inequality — have here been demonstratively worked out into numbers from sound observations. I have no doubt that they are everywhere correct, and that they have been carried to as much precision as the perception of the human eye can sustain. The Sun's path, at least for these present times, has been surveyed as exactly as it ought to be; it can no longer lie hidden — which, for most of the centuries gone by, has up to now been its fate.

[Margin note marker: "9" — printed in the left margin beside the start of this paragraph (paragraph or section number).]

But if anyone should presume to raise some hesitation on this point, or should otherwise be eager to put it to the test, let him see to it that instruments are made of solid metal, precisely worked, and of such size that they can distinctly take in not only the individual whole minutes [scrupula prima], but a sixth of these — or at the very least a third part. For exact scrupulous accuracy [scrupulositas] is required in this practical work, because at the solstice [☉, here the Sun's standstill] — or close to the equinoxes themselves — where the declination changes more rapidly, by as little as a third part of a single minute, a quantity altered in altitude or declination shifts the longitude by a whole minute. Moreover, it is useful in this delicate investigation to rely not on a single astronomical instrument but to bring several to bear — three or four, say, built on different principles, or however many are at hand — so far as expense (and no small expense is required) and the other necessities allow.

And let care be taken that not only all the divisions on these instruments are laid out with the most refined and accurate diligence, but also that the sights [pinnacidia] and the plumb-lines [perpendicularia] are circumspectly attended to, so that everything may be arranged as exquisitely as possible, free of any fault. But as for the making of these and similar instruments — on the model of those that I built some years ago, and which are still in use — since I have dealt with them in a separate volume which I have entitled [continues: "the *Mechanica*..."]

will cover the part dealing with the restoration of astronomy, I have resolved to treat it briefly and clearly (with the favor of Heaven, its own Maker), and I now think it best to set aside any longer exposition. I will at least give this brief warning: unless the instruments at hand are of proper size, immune to the effects of the open air [aërea mutatio], and free in every respect from any defect on every side, then whoever undertakes this work does so in vain, and he would do better to take his hand from the tablet. For this very thing has so far either deceived many or left them doubtful and uncertain. So much so that even that distinguished philosopher of the Italians in the previous age, Hieronymus Cardanus [Girolamo Cardano], did not hesitate, in that little book which he wrote on the restoration of times and motions (with what reliability and certainty I do not say), to assert that the course of the Sun cannot at all be exactly observed, on the grounds that such an inquiry could not be made sufficiently precise by means of instruments.

So then, once reliable and suitable instruments have been obtained, before anything else let there be observed, for the locality where one intends to investigate the Sun and the other heavenly bodies, the altitude of its pole [Poli eius loci sublimitas]. This should be done by way of some of the circumpolar stars, since they stand at their greatest and least altitude. One should choose for this purpose above all the star that does not come within thirty degrees of the horizon, so that the hindrance of refractions in the lower region may be entirely excluded. And for this task none of all the stars is more suitable than the Pole Star itself, which also describes the smallest circuit. Once the elevation of the pole is known in this way — not only to the minute, but even to a sixth or a third part of a single scruple at the least (for so great a precision is required in this place) — then through its complement to a quadrant the inclination of the equator will not be unknown. After that, on individual days let the meridian altitude of the Sun be taken most carefully, its rays being admitted through a suitable channel...

channel into the lower part of the sights [Pinnacidia], so that they may not be scattered by the bright air and may be less visible to the eye. To this let the parallax of the Sun be added; and if it should be so low that it is subject to a perceptible refraction, let that obstacle be subtracted from the altitude already corrected for parallax. For parallax makes the Sun appear lower than it should to us situated on the surface of the Earth, whereas refraction, on the contrary, makes that same Sun appear higher than is right. But as for how these are to be investigated and applied, we shall say more later. The true altitude of the Sun will reveal its declination at the same time, namely by subtracting the elevation of the equator, in the northern signs, from the corrected altitude of the Sun — or, in the southern signs, the latter from the former. This declination, moreover, discloses the longitude of the Sun, once the greatest obliquity of this age is assumed, $23^{\circ} 31\frac{1}{2}'$. For in a right triangle one side is given by the maximum declination just stated; therefore the third side, opposite the right angle, will not be hidden, and this shows the distance of the Sun from the vernal or autumnal equinox, measured along the path of the ecliptic. Or else we may carry out the same thing more easily and readily by means of a table of solar declinations, such as the one we shall append later, diligently calculated for every sixth of a degree. And so, the place of the Sun having thus been found, a test can be made of whether or not it agrees with our restitution. For indeed, if everything is carried out properly, the difference will be found either nil or such as to be wholly imperceptible. Yet this one thing must be attended to: in the two signs nearest to each of the Tropics, the place of the Sun cannot be safely enough tracked down by means of its declination — namely in Gemini and Cancer [II and VI], and likewise in

Sagittarius and Capricorn [♐ and ♑] — for the reason that there it changes its declination very little in the course of a single day.

But just how the longitude of the Sun is to be computed from these foregoing tables, there is no need for me to explain at length here, since the procedure is the same as in other astronomical canons assigned to this office. For once the simple motion both of the apogee and of the longitude has been collected for a given time, and the former subtracted from the latter, the distance of the Sun from the apogee is obtained, by means of which we shall hunt out in the table of prosthaphaereses the equation that corresponds to it. This is to be subtracted from the simple motion of the Sun up to the semicircle, but added after the completion of the semicircle — just as is also indicated at the head and foot of the table. But these matters are too well known to need any further explanation. For we have set out to write these things not for beginners in this art, but for the knowledgeable and the practiced.

Now it is fitting to illustrate the foregoing by a few examples — partly so that the method of finding the place of the Sun from an observed altitude, and comparing it with our numbers, may be more readily established; partly so that the truth of our correction in the matter of the Sun's course may stand out more clearly and surely through the observations of others in various parts of the Earth, separated even by a long stretch of years. And this we shall now do in the following manner.

That most renowned and most outstanding of German mathematicians, Johannes de Montereio [Regiomontanus], a Franconian, among the few solar observations he left behind (which his pupil Bernhard Walther [Bernhard Walther] — of whom I made mention some years back — continued for a number of years), gives, among others, the chord of the Sun's distance from the vertex, observed by him at Nuremberg in the year 1473, on April 20, as 59975. This alone he calls a careful one. To it there corresponds an arc of $34^{\circ} 54'$, which discloses the distance of the Sun from the zenith, and therefore at the same time its altitude of $55^{\circ} 6'$...

to which the parallax adds $1\frac{1}{2}'$, so that the true altitude, with respect to the center of the Earth, is $55^{\circ} 7\frac{1}{2}'$. But the altitude of the equator at Nuremberg, obtained above by us through the elevation of the pole, is $40^{\circ} 34'$. If this is subtracted from the found altitude of the Sun — because at that time the Sun occupies the northern semicircle — it leaves the Sun's northern declination from the equator known as $14^{\circ} 33\frac{1}{2}'$. To this there corresponds on the ecliptic, by the manner indicated earlier, $9^{\circ} 3'$ of Taurus [♉], and this on the assumption here of the greatest declination of the ecliptic as exactly $23^{\circ} 31'$, such as it is likely to have

been around that time, as is also sufficiently gathered from the Waltherian observations adduced above.

And now let us see how this place of the Sun agrees with our reckoning. The simple advance of the apogee for the appointed time is found to be 3 signs $4^{\circ} 3' 45''$. The mean motion of the longitude of the Sun is 1 sign $7^{\circ} 22' 12''$; and if from this we subtract the place of the apogee, there will be left the distance of the Sun from the higher apse, by the order of the signs, 10 signs $3^{\circ} 18' 27''$. To this, from the table of prosthaphaereses, there corresponds an equation of $1^{\circ} 56' 56''$, to be added to the simple motion so that the apparent place may be established. And so the true place of the Sun, reckoned from the vernal equinox, comes out as $9^{\circ} 3' 8''$ of Taurus [♉] — and this beneath the meridian of this place. But because we are more easterly than the Nurembergers by about a quarter of an hour, as was also said before, there must be added for the interval of the meridians 37 seconds, so that the true place of the Sun at that time, on the meridian of Nuremberg, will have been $9^{\circ} 3' 4\frac{1}{2}''$ of Taurus [♉]. This differs only very slightly from our numbers — indeed, the discrepancy that arises is almost imperceptible. Owing to the eccentricity of the Sun, which was somewhat smaller at that time, the assumption being a little less, whereby the prosthaphaeresis too is somewhat constricted, it all but vanishes.

It is clear, therefore, that the Sun's place agrees well enough with our reconstruction, as derived from the more careful observation Regiomontanus [Regiomontanus] made at Nuremberg [Nuremberg] more than a hundred years ago. But if we apply the Alphonsine reckoning [Alphonsine numeration], it gives the Sun's place at $9^{\circ} 15' 8''$, exceeding by 12'. The Copernican value, by contrast, comes closer here: it yields a longitude of $9^{\circ} 6' 8''$, and on that account exceeds by only three minutes. This happens incidentally, because the Sun, taken simply from the vernal equinox, has moved out about 10' farther than it should, while the prosthaphaeresis [prosthaphaeresis] falls short by eight minutes (very nearly as much). For this reason, since these two corrections offset each other by mutual cancellation — a deviation that would otherwise turn out far greater — the Copernican calculation does not diverge much here.

We shall find the same to hold around the autumnal equinox of that same year. For the values Regiomontanus obtained at the vernal equinox do not agree among themselves. Thus, on the 13th of September of that same year, 1473, he recorded a chord for the distance of the Sun from the zenith [a Vertice] of 83200, to which corresponds an altitude of $40^{\circ} 50' 4''$. Parallax [Parallax] adds $1' 2'' 16'''$, so that the true elevation is $40^{\circ} 52' \frac{1}{2}$. From this, with the inclination of the

equator at Nuremberg subtracted, there remains a declination of $0^{\circ} 18' \frac{1}{2}$ North. To this corresponds, according to the longitude on the ecliptic, $29^{\circ} 14'$ Virgo [♍]. On the following day he established a chord from the zenith of 83810, whence the apparent altitude of the Sun was $40^{\circ} 27'$; the true altitude was $40^{\circ} 29' 17''$. If this is subtracted from the elevation of the equator, the result is a southern declination of $0^{\circ} 4' 43''$, and accordingly a longitude of about $0^{\circ} 12'$ Libra [♏, very nearly]. These two places of the Sun observed around the autumnal equinox correspond well enough with each other, except that they make the daily motion slower by very nearly a single minute than it should be. It will therefore be advisable to subtract half a minute from the longitude in the earlier observation, so that it becomes

more accurate at $29^{\circ} 13' \frac{1}{2}$ Virgo [♍]; and to add just as little to the later one, so that it comes out at $0^{\circ} 12' \frac{1}{2}$ Libra [♏]. For then everything will be more correctly analogous to the celestial standard itself, and will depart only imperceptibly from the numbers of our correction. Indeed, our calculation gives the Sun's place on the 13th of September at $29^{\circ} 14'$ Virgo [♍], which agrees well enough. The same is to be judged of the 14th of September, when our numbers exhibit a longitude of the Sun of $0^{\circ} 13'$ Libra [♏]. If we call the Alphonsine calculation into consultation, it will give, on the 13th of September, a longitude of the Sun of $29^{\circ} 17'$ Scorpio [♏], and accordingly greater than it should be by $3\frac{1}{2}$ minutes. The Copernican numeration, on the other hand, produces for that time a longitude of $29^{\circ} 36'$ Scorpio [♏], which exceeds Regiomontanus's observation by more than 12 minutes. And such differences likewise occur on both sides on the following day. Let it suffice to have shown this from the more select observations of Regiomontanus.

[Margin: 15]

By the same method we shall further compare certain more accurate observations of his disciple Walther [Bernhard Walther], and first one made 20 years later — namely in the year 1493, on the 23rd of September — which he commends above the rest in these words: "The sky was perfectly clear, whence the observation was most diligent and excellent; if others should correspond to it, let them all be judged reliable." On that day he sets down a chord for the distance from the zenith of 89460, to which corresponds an altitude of the Sun of $36^{\circ} 51' 40''$. Parallax adds $1' 2'' 24'''$, of which, however, the $24'''$ can be left aside, since refraction [refraction] insinuates itself somewhat there, so that the true altitude — free of parallax and refraction — is $36^{\circ} 53' 40''$ Libra [♏]. Accordingly the declination of the Sun is $3^{\circ} 40' 20''$, to which corresponds a longitude of $5^{\circ} 14' \frac{1}{4}$

Libra [♎]. Our calculation gives $9^{\circ} 15'$ Libra [♎], with an imperceptible intervening difference. But the Alphonsine value exceeds by about $5'$, while the Copernican is in excess by nearly $18'$.

But coming a little closer to the age of Copernicus [Copernicus], we shall test what the same Walther shows in the last two

years of his observations, and first in the year 1503, on the 27th of April, when he says he found a clear and most certain chord from the zenith of 56636, to which corresponds an altitude of the Sun of $57^{\circ} 1' 6''$. Corrected by parallax, $57^{\circ} 1' 7''$ ☉. Accordingly the declination is $16^{\circ} 33' 37''$, and the longitude $15^{\circ} 35' 8''$ [Taurus, by context]. Our reckonings give $15^{\circ} 34' 8''$, which differs very slightly. The Alphonsine computation has $15^{\circ} 43' 8''$, in excess by 8 minutes; the Copernican, however, $15^{\circ} 30' \frac{1}{2} 8''$, falling short by very nearly 5 minutes. Likewise in the following year, 1504, on the 18th of March, there comes out a distance from the zenith of 78990, which he calls a clear and most exact one, to be relied upon. To this corresponds an altitude of the Sun of $43^{\circ} 28' 26''$, corrected by parallax to $43^{\circ} 30' 36''$; whence a northern declination of $2^{\circ} 56' 36''$, and on that account a longitude of $7^{\circ} 23' \frac{1}{2}$ Aries [♈]. Our calculation yields exactly the same place. But the Alphonsine is in excess by very nearly a quarter of a degree, while the Copernican falls short by 9 minutes. Let it suffice to have examined this much concerning the Waltherian observations.

[Margin: 19]

Indeed, bringing this matter gradually down to our own times as well — especially around these very years in which the New Star (with which this Book is concerned) appeared — we shall make the same trial. Therefore, on working through several years' observations of the Sun communicated to me by the most illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel], I find that by means of the quadrants which His Highness then had in use, the meridian altitude of the Sun was observed in the year 1572 on the 7th of March at $37^{\circ} 28' \frac{1}{2}$, to which parallax adds $1' 2'' 22'''$. But with these $22'''$ set aside on account of the refraction that somewhat intrudes itself, the true elevation will be $37^{\circ} 30' \frac{1}{4}$. And since the elevation of the equator there is such that, as

indicated above, it is $38^{\circ} 41'$, the Sun's declination comes out at $1^{\circ} 10' \frac{1}{2}$ South — which agrees exceedingly well also with the notation of that most cultivated gentleman and most devoted lover of these arts, Master Paul Hainzel [Paul Hainzel], at that time consul of the Republic of Augsburg [Augsburg], who has now departed life. For among the observations of the Sun made with the great

quadrant — which I myself helped to construct there, on his estate outside the city (about which I shall say more under the 4th Caput, when I describe its form and size), while I was staying at Augsburg — those which were made some years ago, after I had departed thence to Denmark, he sent here to me; and I find for the 7th of March a declination assigned in his own hand of $1^{\circ} 10' \frac{1}{2}$. So that the matter may be confirmed by a double testimony, that it stands correctly. Now to this declination corresponds a longitude of the Sun of $27^{\circ} 3' \frac{3}{4}$ Pisces [✕]. Our calculation gives $27^{\circ} 2' \frac{1}{2}$, the difference of meridians adding nearly a minute. And so the Sun's place, from observation, agrees quite precisely with our indication. But the Alphonsine, giving its position then at $27^{\circ} 19'$ Pisces [✕], is in excess by more than a quarter of one degree. The Copernican, on the other hand, placing it at $26^{\circ} 36'$ Pisces [✕], falls short by very nearly 27 minutes — by almost half a degree.

[Margin: 24]

Likewise, in the following year, 1573, on the 4th of March, the aforesaid most illustrious Prince observed the meridian altitude of the Sun at Kassel [Cassel] as $36^{\circ} 10'$. Parallax adds $1' 2'' 25'''$; but with the seconds set aside on account of refraction, as before, the true altitude will be $36^{\circ} 12'$, and accordingly a southern declination of $2^{\circ} 1' 29''$, whence the Sun's longitude comes out at $23^{\circ} 46'$ Pisces [✕]. But near Augsburg, from the altitude observed there by the aforesaid Consul Heinzel, and corrected by parallax, the Sun's declination is gathered to be $2^{\circ} 25' 40''$, to which corresponds

corresponds a longitude of $23^{\circ} 54\frac{1}{3}'$ Pisces. But our theory of the motions gives the place of the Sun as $23^{\circ} 50'$ Pisces, which falls midway between the two observations. It therefore turns out, with good probability, that this latter figure is the more correct. It would easily have been possible for the Augsburg observation to be one and a half minutes too large, and the Kassel one short by almost the same amount; once that adjustment is made, the two agree better with each other. Thus the mean declination observed at those two places, [Margin: 2] $1^{\circ} 27\frac{1}{2}'$, yields a solar longitude of $23^{\circ} 50'$ Pisces, in close agreement with our reasoning. The Alphonsine calculation, however, exceeds this by somewhat more than a quarter of a degree, while Copernicus's falls short of the same value by $27'$, almost half a degree — as has also happened in both cases earlier.

But to bring something forward here from our own findings as well: here I shall present an accurate observation made near the winter solstice, [Margin: 14] carried out by a special method in the year 1586, with the aim of testing the Sun's motion around perigee as well. The purpose was to forestall any objection that

we had relied only on intermediate places near the equinoxes, where any error in apogee or perigee — even one of several degrees — varies the Sun's apparent course only imperceptibly, so that it could be inferred from those places alone that our eccentricity is indeed correct but our apogee is not. For that reason we shall make the attempt especially around the winter solstice. This is better suited to observation in these northern regions than the summer solstice, both because of the very bright summer nights and the Sun's long stay above the horizon, and for other reasons that do not allow the method of solstitial observation we have devised to be carried out equally well in summer as in winter.

In the year just mentioned, 1586, on 2 December, I observed the Sun reach the meridian point at very nearly the 259th degree of the equator, 20'. By careful attention paid both morning and evening, the places of Jupiter and Venus were corrected by means of the fixed stars, and a comparison was also made with the inerrant stars, so that the measure of the time in which that transit occurred could be discerned precisely with respect to a fixed star — as I shall perhaps explain more fully elsewhere. To this right ascension corresponds a solar longitude, as will appear from a table that we shall add a little later, of 20°12' Sagittarius [Margin: 20], whereas our tables supply for the same time 20°12½' Sagittarius, longer by only half a minute.

In the same way — to approach perigee still more closely — on 16 December of the same year, in the morning by means of Spica Virginis, and in the evening by means of the star of Venus, as soon as it appeared, the measure of the interval of the solar transit across the meridian was verified, derived from a star fixed and previously well explored; and I found its right ascension, when it was on the meridian itself, to be 274°55' [Margin: ?]. To this corresponds 4°30½' Sagittarius on the ecliptic, which agrees very precisely with our computation, which gives at that time the place of the Sun as 4°30¾' Sagittarius. With the Alphonsine calculation, here as before, it is in excess by about a quarter of a degree; with the Copernican it falls short, again in both cases, by roughly a quincunx of degrees [i.e. about five-twelfths of a degree].

It is therefore established that around perigee too the place of the Sun derived from our tables agrees properly with celestial observation. Nor is there any reason for anyone to suspect that refraction or its parallax in that low position introduces any impediment: [Margin: 13] for these could affect only the declination of the Sun, not its right ascension, and the longitude derived from that.

The same thing I also hold to be well established from the eclipse of the Moon of the year 1573, which occurred on 8 December, with the Sun not long before its perigee. That is, its course around the lowest point of the orbit, and therefore near apogee as well, agrees with our calculation just as aptly as in the other intermediate places — as I shall show more fully on another, more suitable occasion. Rheticus does indeed report of Copernicus that he examined, by means of lunar eclipses, the apogee of the Sun that he had himself established, occurring near this point; but whoever was able to do that — given that he neither corrected the Moon's place properly, nor knew the precise positions of the fixed stars, and several other things needed for the purpose were lacking in his work — I am by no means convinced of it. Let this much, said in confirmation of our emendation of the solar motion by means of several worked observations, suffice.

[Margin: 7] Now I shall append the tables that are required for this purpose: first, that of refractions, explored through frequent experiment; next, that of parallaxes; then that of the ecliptic declinations, for every ten minutes of degree; and last, that of right ascensions — the final two of which bear on our finding regarding the maximum declination. Afterwards I shall set out, with a brief and concise note, the construction and use of these tables.

TABLE OF SOLAR REFRACTIONS

[Tabula Refractionum Solarium]

This little table of the refractions that present themselves to the eye when looking toward the Sun — small indeed, but compiled with great and long labor through very frequent observations — shows the difference by which the Sun, in our climate, appears higher in the vertical circle, by refraction, than it really is. And although this has been carefully worked out from many observations compared against one another, and although these refractions, which mostly arise in a clear sky, are diligently determined here, nevertheless, because the purity of the air is not always the same, it can happen that they sometimes present themselves half a scruple, or perhaps even nearly a whole one, less or more than the value here — especially in the first roughly 20 parts of altitude, where, the Sun being lower, it is more exposed to the impediment and variety of vapors. For this reason I have constructed the earlier column of the table at least to the individual minutes, or to their halves, or at the very least to quarters, since a finer scrupulosity there would be idle and useless. In the other column, however, where the Sun is higher and less hindered by terrestrial exhalations, I have applied a somewhat more exact treatment, with a limitation to tens, or at most to fives, of seconds of scruples.

It can also happen that these very values behave a little differently on different horizons, because the air is not everywhere of the same nature and temperament. For that reason I judged it superfluous to have indicated these things too scrupulously. Nonetheless I hope to present this very table of solar refractions, with however broad an indication, in such a way that nothing should be wanting that could sensibly hinder observation in a purer state of the air. For the constitution of the air must be most serene and most cleared when the experiment for this matter is set up. The means by which it may be more skillfully carried out we shall give afterwards. I have, moreover, carried the final limit of the refractions down to the midpoint of the quadrant of the circle, since around this limit they turn out to be very much attenuated, indeed insensible, and afterwards vanish altogether.

Alt. ☉ (G.)	Refr. '	Refr. "	Alt. ☉ (G.)	Refr. '	Refr. "
0	34	0	23	3	10
1	26	0	24	2	50
2	20	0	25	2	30
3	17	0	26	2	15
4	15	30	27	2	0
5	14	30	28	1	45
6	13	30	29	1	35
7	12	45	30	1	25
8	11	15	31	1	15
9	10	30	32	1	5
10	10	0	33	0	55
11	9	30	34	0	45
12	9	0	35	0	35
13	8	30	36	0	30
14	8	0	37	0	25
15	7	30	38	0	20
16	7	0	39	0	15
17	6	30	40	0	10
18	5	45	41	0	9
19	5	0	42	0	8
20	4	30	43	0	7

Alt. ☉ (G.)	Refr. ′	Refr. ″	Alt. ☉ (G.)	Refr. ′	Refr. ″
21	4	0	44	0	6
22	3	30	45	0	5

TABLE OF SOLAR PARALLAXES IN THE VERTICAL CIRCLE, ACCORDING TO ITS THREEFOLD DISTANCE FROM THE EARTH

[Tabula Parallaxium Solarium in Circulo Verticali ad eius a Terra remotionem triplicem]

This table gives the Sun's parallax in the vertical circle for each degree of altitude (0–90), at three distances from the Earth — Maximum, Mean, and Minimum [Maxi: / Media / Min:]. It is printed in three vertical panels: altitudes 0–30 at the left, 31–59 in the middle, and 60–90 at the right; each panel carries the three parallax columns in minutes and seconds. The transcription below restores it to a single continuous run of altitude.

Alt. (G.)	Max ′	Max ″	Media ′	Media ″	Min ′	Min ″
0	2	54	3	0	3	7
1	2	54	3	0	3	7
2	2	54	3	0	3	7
3	2	54	3	0	3	7
4	2	53	2	59	3	6
5	2	53	2	59	3	6
6	2	53	2	59	3	6
7	2	52	2	58	3	5
8	2	52	2	58	3	5
9	2	51	2	57	3	4
10	2	51	2	57	3	4
11	2	50	2	56	3	3
12	2	50	2	56	3	3
13	2	49	2	55	3	2
14	2	48	2	54	3	1
15	2	48	2	54	3	0

Alt. (G.)	Max ´	Max ¨	Media ´	Media ¨	Min ´	Min ¨
16	2	47	2	53	2	59
17	2	46	2	52	2	58
18	2	46	2	51	2	58
19	2	45	2	50	2	57
20	2	44	2	50	2	56
21	2	43	2	49	2	55
22	2	42	2	48	2	53
23	2	41	2	46	2	52
24	2	40	2	45	2	50
25	2	38	2	44	2	49
26	2	37	2	43	2	47
27	2	35	2	41	2	45
28	2	33	2	39	2	44
29	2	31	2	37	2	43
30	2	30	2	36	2	42
31	2	28	2	34	2	40
32	2	27	2	32	2	38
33	2	25	2	30	2	37
34	2	23	2	29	2	35
35	2	22	2	27	2	33
36	2	20	2	25	2	31
37	2	18	2	23	2	29
38	2	17	2	21	2	27
39	2	15	2	19	2	25
40	2	13	2	18	2	23
41	2	11	2	16	2	21
42	2	9	2	14	2	19
43	2	7	2	12	2	17
44	2	5	2	9	2	15
45	2	3	2	7	2	12
46	2	1	2	5	2	10

Alt. (G.)	Max ´	Max ¨	Media ´	Media ¨	Min ´	Min ¨
47	1	59	2	3	2	8
48	1	57	2	0	2	5
49	1	55	1	58	2	3
50	1	52	1	56	2	0
51	1	50	1	54	1	58
52	1	47	1	51	1	55
53	1	45	1	48	1	52
54	1	43	1	46	1	50
55	1	40	1	43	1	47
56	1	38	1	41	1	45
57	1	35	1	39	1	42
58	1	32	1	36	1	39
59	1	30	1	33	1	36
60	1	27	1	30	1	33
61	1	25	1	28	1	31
62	1	22	1	25	1	28
63	1	19	1	22	1	25
64	1	16	1	19	1	22
65	1	13	1	16	1	19
66	1	10	1	14	1	17
67	1	8	1	11	1	14
68	1	5	1	8	1	11
69	1	2	1	5	1	8
70	0	59	1	2	1	5
71	0	56	0	59	1	2
72	0	53	0	56	0	59
73	0	50	0	53	0	56
74	0	47	0	49	0	52
75	0	45	0	46	0	48
76	0	42	0	43	0	45
77	0	39	0	40	0	41

Alt. (G.)	Max ′	Max ″	Media ′	Media ″	Min ′	Min ″
78	0	36	0	37	0	38
79	0	33	0	34	0	35
80	0	30	0	31	0	32
81	0	27	0	28	0	29
82	0	24	0	25	0	25
83	0	21	0	21	0	22
84	0	18	0	18	0	19
85	0	15	0	15	0	16
86	0	12	0	12	0	13
87	0	9	0	9	0	9
88	0	6	0	6	0	6
89	0	3	0	3	0	3
90	0	0	0	0	0	0

Table of the Ecliptic Declination — Book I

TABLE OF THE ECLIPTIC DECLINATION (p. 81)

TABVLA DECLINATIONIS ECLIPTICAE — Table of the Ecliptic Declination.

The table gives the declination [declinatio] of each point of the ecliptic from the equator, computed at the author's greatest declination (obliquity) [maxima declinatio] of about 23°31′, tabulated to every ten minutes of longitude. The left-hand argument runs in degrees (**G.** = *gradus*) and minutes (**M.** = *minuta*, in steps of 10′). Each of the three sign-pair blocks gives the declination in degrees (**P./i.** = *partes*), minutes (′), and seconds (″), followed by its first-difference column (**Diff. A.**, in minutes and seconds). The block headers at the top name the ascending signs (♈ Aries / ♎ Libra; ♉ Taurus / ♏ Scorpio; ♊ Gemini / ♐ Sagittarius); the complementary signs are named at the foot of each block (♊ Pisces / ♍ Virgo; ♋ Aquarius / ♌ Leo; ♏ Capricorn / ♋ Cancer), with the right-hand argument (**M. / G.**) read upward for those signs.

The first-difference (Diff.) values are printed in the source offset by half a row, between consecutive declination entries. They are reproduced here on the line of the *upper* entry of each pair (i.e., the difference added in passing from that row to the next).

Page 81 — argument 0°00' to 5°00'

$\gamma/\underline{\alpha}$ P.	Diff.A. ' " '	$\gamma/\underline{\alpha}$ P.	Diff.A. ' " '	Π/γ " P.	Diff.A. ' " '	"
0	0 0 4	0 11	3 4 3 0 3	3 20 2	1 2 2 3 2	7
0	4 0 3	5 11 9	3 1 3 4 5	3 20 1	1 2 2 5 9	7
0	7 5 3 9	5 11 9	3 4 3 7 6	3 20 1	1 3 2 7 6	6
0	1 5 3 1 8	5 11 9	4 1 3 1 7	3 20 1	1 4 2 9 2	5
0	1 5 3 5 7	5 11 9	4 4 3 4 8	3 20 0	2 4 2 1 7	5
0	1 5 4 9 6	0 11	4 1 3 8 8	3 20 0	2 5 2 3 2	5
0	2 5 3 3 6	5 11 9	5 4 3 1 8	2 20 9	2 5 2 5 7	4
0	2 5 3 7 5	5 11 9	5 1 3 5 7	2 20 9	2 1 2 8	3
0	3 5 4 1 5	0 11	5 4 3 8 6	2 20 9	3 4 2 0	2
0	3 5 3 5 5	5 12 9	2 1 3 5	2 20 9	3 6 2 2	1
0	3 5 3 9 4	5 12 9	5 4 3 4	2 20 8	3 7 2 4	1
0	4 5 4 3 3	0 12	9 1 3 2	2 20 8	3 8 2 6	1
0	4 5 3 7 3	5 12 9	1 4 3 2 0	2 20 8	3 9 2 8	0
0	5 5 4 1 2	0 12	1 8 3 6	2 20 7	4 9 1 0	5 9
0	5 5 3 5 2	5 12 9	1 3 3 9 5	2 20 7	4 8 1 2	5 9
0	5 5 3 9 1	5 12 9	2 2 3 3	2 20 7	4 6 1 4	5 8

Υ/♊ P.	Diff.A.			♈/♏ P.	Diff.A.			♏/♏ P.	Diff.A.					
	'	"	'	"	'	"	'	"	'	"	'	"		
0 [recte: 1?]	3	5	3	5	12	2	2	3	2	20	4	4	1	5
		0		9		6	9		6		6			8
1	7	4	4	0	12	2	5	3	2	20	4	1	1	5
		9				9	5		6		8			7
1	1	4	3	5	12	3	2	3	2	20	4	5	1	5
		1	9	9		3	1		5		9	8		7
1	1	4	3	5	12	3	4	3	2	20	5	5	1	5
		5	8	9		6	6		6		1	4		6
1	1	4	3	5	12	4	1	3	2	20	5	4	1	5
		9	7	9		0	2		5		3	9		5
1	2	4	3	5	12	4	3	3	2	20	5	4	1	5
		3	6	9		3	7		4		5	4		5
1	2	4	3	5	12	4	1	3	2	20	5	3	1	5
		7	5	9		7			4		7	8		4
1	3	4	3	5	12	5	2	3	2	20	5	3	1	5
		1	4	9		0	5		4		9	2		4
1	3	4	3	5	12	5	4	3	2	21	1	2	1	5
		5	3	9		3	9		3		5			3
1	3	4	3	5	12	5	1	3	2	21	3	1	1	5
		9	2	9		7	2		3		7			2
1	4	4	3	5	13	0	3	3	2	21	5	9	1	5
		3	1	9		5			3					2
1	4	4	3	5	13	3	5	3	2	21	7	0	1	5
		7	0	9		8			3					1
1	5	3	3	5	13	7	2	3	2	21	8	5	1	5
		1	9	9		1			2		0			0
1	5	3	3	5	13	1	4	3	2	21	1	4	1	5
		5	8	2		0	3		2		0	0		0
1	5	3		13		1	5		21		1	2	1	4
		9	7			4					2	9		9

Foot signs (read upward): block 1 ♋ Pisces / ♍ Virgo [engraved foot symbols * ♍]; block 2 ♒ Aquarius / ♌ Leo; block 3 ♐ Capricorn / ♋ Cancer. Foot label of each difference column: **Diff. S.**

TABLE OF THE ECLIPTIC DECLINATION (continued, p. 82)

AD GRADVVM DENA SCRVPVLA EXTENSA, — *extended to every ten minutes of the degrees.*

Page 82 — argument 5°00' to 10°00'

Υ/♌ P.	Diff.A ' " .'	♍/♍ P.	Diff.A ' "	♎/♎ P.	Diff.A ' " .'
1	5 3 3 9 7	5 13 9	1 5 4	3 2 21 1	1 2 1 2 8
2	3 3 3 6	5 13 9	1 26 7	3 2 21 1	1 1 1 4 6
2	7 3 3 5	5 13 8	2 47 0	3 2 21 1	1 4 1 6
2	1 3 3 1 3	5 13 8	2 8 4	3 2 21 1	1 5 1 7 1
2	1 3 3 5 1	5 13 8	2 28 7	3 2 21 0	1 3 1 9 7
2	1 3 3 9 0	5 13 9	3 48 0	3 2 21 0	2 2 1 1 3
2	2 2 3 3 8	5 13 8	3 7 4	3 1 21 9	2 7 1 3
2	2 2 3 7 6	5 13 8	3 20 7 [recte: 26?]	3 1 21 9	2 5 1 4 2
2	3 2 3 1 4	5 13 8	4 45 0	3 1 21 9	2 3 1 6 6
2	3 2 3 5 2	5 13 8	4 4 4	3 1 21 8	2 1 1 8 8
2	3 2 3 9 0	5 13 8	4 22 7	3 1 21 8	3 0 1 0
2	4 1 3 3 8	5 13 8	5 40 0	3 1 21 7	3 4 1 1 2
2	4 1 3 7 6	5 13 8	5 57 3	3 1 21 7	3 2 1 3 2
2	5 1 3	5 13	5 14	3 1 21	3 2 1

$\Upsilon/\underline{\Omega}$ P.	Diff.A ' " . '	$\mathcal{V}/\mathcal{M}$ " P.	' "	Diff.A ' "	" $\Pi/\mathcal{X}$ P.	Diff.A ' " . '	"
	1 4	8	7		6	5	0
2	5 1 3	5 14	0 30	3	1 21	3 4 1	4
	5 2	8			6	6 3	1
2	5 1 3	5 14	3 46	3	1 21	3 2 1	3
	9 0	8			6	8 2	9
3 [rect e]	3 8 3	5 14	7 2	3	1 21	4 0 1	3
		8			5	0	8
3	7 6 3	5 14	1 17	3	1 21	4 3 1	3
		8	0		5	1 8	7
3	1 4 3	5 14	1 32	3	1 21	4 1 1	3
	1	8	3		4	3 5	6
3	1 2 3	5 14	1 46	3	1 21	4 5 1	3
	5	7	6		4	4 1	5
3	1 5 3	5 14	2 0	3	1 21	4 2 1	3
	8 9	7	0		4	6 6	5
3	2 5 3	5 14	2 14	3	1 21	4 1 1	3
	2 6	7	3		3	8	4
3	2 5 3	5 14	2 27	3	1 21	4 3 1	3
	6 3	7	6		3	9 5	3
3	3 5 3	5 14	2 40	3	1 21	5 9 1	3
	0 0	7	9		3	1	2
3	3 4 3	5 14	3 53	3	1 21	5 4 1	3
	4 7	7	2		2	2 2	1
3	3 4 3	5 14	3 5	3	1 21	5 1 1	3
	8 4	7	6		2	4 4	1
3	4 4 3	5 14	3 17	3	1 21	5 4 1	3
	2 1	7	9		2	5 5	0
3	4 3 3	5 14	4 28	3	1 21	5 1 1	3
	6 8	7	2		1	7 6	0
3	5 3 3	5 14	4 39	3	1 21	5 4 1	2
	0 5	7	5		1	8 6	9
3	5 3 3	5 14	4 49	3	1 21	0 1 1	2

Υ/Ϸ	Diff.A			Ϻ/ℳ	Diff.A			Π/ϣ	Diff.A		
P.	'	"	.	"	P.	'	"	P.	'	"	.
	4	2		6	8			0	[recte: 22?]	6	8
3	5	2		14	5	59		21		1	4
	8	8			1			[recte: 22?]		5	

Foot signs (read upward): block 1 ϥ / ϭ; block 2 ϭ / ϭ; block 3 ϭ / ϭ. Foot label of each difference column: **Diff. S.**

TABLE OF THE ECLIPTIC DECLINATION (continued, p. 83)

QVAE MAXIMAM HVIVS NOSTRI SECVLI — *which [matches] the greatest [obliquity] of this our age.*

Page 83 — argument 10°00' to 15°00'

Υ/Ϸ	Diff.A.			Ϻ/ℳ	Diff.A.			Π/ϣ	Diff.A.		
P.	'	"	.	"	P.	'	"	P.	'	"	.
3	5	2	3	5	14	5	5	1	22	1	4
	8	8		6		1	9	0		5	
4	2	2	3	5	14	5	9	9	22	3	1
	4			6		5				3	
4	6	2	3	5	14	5	1	9	22	4	4
	0			6		8	8			0	
4	1	1	3	5	15	1	2	8	22	6	6
	0	6		6		7					
4	1	1	3	5	15	4	3	8	22	7	3
	4	2		6		5				2	
4	1	8	3	5	15	7	4	7	22	8	5
	8			6		3				7	
4	2	4	3	5	15	1	5	7	22	1	2
	2			6		0	0			0	2
4	2	0	3	5	15	1	5	7	22	1	4
	6			6		3	7			1	6
4	2	5	3	5	15	1	4	6	22	1	9
	9	6		6		7				3	

$\Upsilon/\underline{}$					$\mathcal{V}/\mathfrak{M}$					$\Pi/\mathcal{X}$							
P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"			
4	3	5	3		5	15	2	1	3		6	22	1	3	1		2
	3	2			5		0	0					4	2			2
4	3	4	3		5	15	2	1	3		5	22	1	5	1		2
	7	7			5		3	6					5	4			1
4	4	4	3		5	15	2	2	3		5	22	1	1	1		2
	1	2			5		6	1					7	5			0
4	4	3	3		5	15	2	2	3		5	22	1	3	1		1
	5	7			5		9	6					8	5			9
4	4	3	3		5	15	3	3	3		4	22	1	5	1		1
	9	2			5		2	1					9	4			9
4	5	2	3		5	15	3	3	3		4	22	2	1	1		1
	3	7			5		5	5					1	3			8
4	5	2	3		5	15	3	3	3		3	22	2	3	1		1
	7	2			5		8	9					2	1			8
5	1	1	3		5	15	4	4	3		3	22	2	4	1		1
	7				4		1	2					3	9			7
5	5	1	3		5	15	4	4	3		2	22	2	6	1		1
	1				4		4	5					5				6
5	9	5	3		5	15	4	4	3		2	22	2	2	1		1
					4		7	7					6	2			5
5	1	5	3		5	15	5	4	3		1	22	2	3	1		1
	2	9			4		0	9					7	7			5
5	1	5	3		5	15	5	5	3		1	22	2	5	1		1
	6	3			4		3	0					8	2			4
5	2	4	3		5	15	5	5	3		1	22	3	6	1		1
	0	7			4		6	1					0				3
5	2	4	3		5	15	5	5	3		0	22	3	1	1		1
	4	1			4		9	1					1	9			3
5	2	3	3		5	16	2	5	3		0	22	3	3	1		1
	8	5			4		1						2	2			2
5	3	2	3		5	16	5	5	2		5	22	3	4	1		1
	2	9			3		1				9		3	4			1
5	3	2	3		5	16	8	5	2		5	22	3	5	1		1

$\Upsilon/\underline{\Omega}$				$\vartheta/\mathfrak{M}$				$\Pi/\mathcal{X}$						
P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"
	6	2		3		0			9		4	5		0
5	4	1	3	5	16	1	4	2	5	22	3	5	1	1
	0	5		3		1	9		8		6			0
5	4	8	3	5	16	1	4	2	5	22	3	1	1	9
	4			3		4	7		8		7	4		
5	4	1	3	5	16	1	4	2	5	22	3	2	1	9
	8			3		7	5		7		8	3		
5	5	5	3	5	16	2	4	2	5	22	3	3	1	8
	1	4		3		0	2		7		9	1		
5	5	4		16		2	3		22		4	3	1	8
	5	7				3	9				0	9		

Foot signs (read upward): block 1 $\times / \mathfrak{M}$; block 2 $\approx / \mathfrak{Q}$; block 3 $\mathfrak{V} / \mathfrak{S}$. Foot label of each difference column: **Diff. S.**

TABLE OF THE ECLIPTIC DECLINATION (continued, p. 84)

EX AVTHORIS ACCVRATIS OBSERVATIONIBVS — *from the author's careful observations.*

Page 84 — argument 15°00' to 20°00'

$\Upsilon/\underline{\Omega}$				$\vartheta/\mathfrak{M}$				$\Pi/\text{\textbackslash}^7$							
P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"	P.	'	"	Diff.A.'	"	
5	5	4	3		5	16	2	3	2	5	22	4	4	1	7
	5	6			2		3	9		6		0	0		
5	5	3	3		5	16	2	3	2	5	22	4	4	1	6
	9	8			2		6	4		6		1	7		
6	3	3	3		5	16	2	3	2	5	22	4	5	1	5
	0				2		9	0		5		2	3		
6	7	2	3		5	16	3	2	2	5	22	4	5	1	5
	2				2		2	5		5		3	8		
6	1	1	3		5	16	3	2	2	5	22	4	3	1	5
	1	4			2		5	0		5		5			
6	1	6	3		5	16	3	1	2	5	22	4	7	1	4
	5				2		8	5		4		6			

$\Upsilon/\underline{}$					$\mathcal{V}/\mathfrak{M}$					$\Pi/\mathcal{X}$				
P.	'	"	Diff.A.	'	"	P.	'	"	Diff.A.	'	"	Diff.A.	'	"
6	1	5	3		5	16	4	9	2	5	22	4	1	1
	8	8			2		1			3		7	0	
6	2	5	3		5	16	4	2	2	5	22	4	1	1
	2	0			2		4			3		8	2	
6	2	4	3		5	16	4	5	2	5	22	4	1	1
	6	2			1		6	5		3		9	4	
6	3	3	3		5	16	4	4	2	5	22	5	1	1
	0	3			1		9	8		2		0	5	
6	3	2	3		5	16	5	4	2	5	22	5	1	1
	4	4			1		2	0		1		1	5	
6	3	1	3		5	16	5	3	2	5	22	5	1	0
	8	5			1		5	1		1		2	4	
6	4	6	3		5	16	5	2	2	5	22	5	1	0
	2				0		8	2		1		3	3	
6	4	5	3		5	17	1	1	2	5	22	5	1	0
	5	6			0			3		0		4	1	
6	4	4	3		5	17	4	3	2	4	22	5	9	0
	9	6			0					9		5		
6	5	3	3		5	17	6	5	2	4	22	5	6	0
	3	6			0			2		9		6		
6	5	2	3		5	17	9	4	2	4	22	5	2	0
	7	6			0			1		9		7		
7	1	1	3		5	17	1	3	2	4	22	5	5	0
	6				0		2	0		8		7	7	
7	5	6	3		5	17	1	1	2	4	22	5	5	0
					0		5	8		7		8	1	
7	8	5	3		4	17	1	5	2	4	22	5	4	0
	5				9		8			7		9	5	
7	1	4	3		4	17	2	5	2	4	23	0	3	0
	2	4			9		0	2		6			8	
7	1	3	3		4	17	2	3	2	4	23	1	3	0
	6	3			9		3	8		6			1	
7	2	2	3		4	17	2	2	2	4	23	2	2	0

Υ/Ϛ				ϣ/ϣ				Π/ϣ			
P.	'	"	Diff.A.	'	"	P.	'	"	Diff.A.	'	"
	0	2		9			6	4		5	2
7	2	1	3	4	17		2	9	2	4	23
	4	1		9			9			5	3
7	2	0	3	4	17		3	5	2	4	23
	8			8			1	4		5	
7	3	4	3	4	17		3	3	2	4	23
	1	8		8			4	9		5	
7	3	3	3	4	17		3	2	2	4	23
	5	6		8			7	3		4	
7	3	2	3	4	17		4	7	2	4	23
	9	4		8			0			4	
7	4	1	3	4	17		4	5	2	4	23
	3	2		7			2	0		3	
7	4	5	3	4	17		4	3	2	4	23
	6	9		7			5	2		2	
7	5	4		17			4	1		23	
	0	6					8	4			

Foot signs (read upward): block 1 ϣ / ϣ; block 2 ϣ / ϣ; block 3 ϣ / ϣ. Foot label of each difference column: **Diff. S.**

Book I — Reference Tables

Table of the Ecliptic Declination (continued)

The two facing pages here continue the **Table of the Ecliptic Declination** [Tabula Declinationis Eclipticae] begun earlier, carrying the argument from 20° up to the summer solstice, where the declination reaches its maximum equal to the obliquity of the ecliptic.

Page 85 — head heading: TROPICORVM OBLIQVITATEM STATVIT

Each declination block lists the whole degrees (P.), arc-minutes ('), and arc-seconds (") of the declination for the head sign-pair, with the first-difference column [Diff. A.] between successive entries. The left argument runs in 10' steps (G. = degrees, M. = minutes); the right argument (M./G.) runs upward as the

complement, with the foot signs ($\times/\mathfrak{M}$, $\approx/\mathfrak{Q}$, $\mathfrak{V}/\mathfrak{S}$) labelling the complementary blocks.

$\Upsilon/\underline{\Omega}$ P.	$\Upsilon/\underline{\Omega}'$	$\Upsilon/\underline{\Omega}''$	Di ff. A.'	Di ff. A."	$\mathfrak{X}/\mathfrak{M}$ P.	$\mathfrak{X}/\mathfrak{M}'$	$\mathfrak{X}/\mathfrak{M}''$	Di ff. A.'	Di ff. A."	$\mathfrak{H}/\mathfrak{S}$ P.	$\mathfrak{H}/\mathfrak{S}'$	$\mathfrak{H}/\mathfrak{S}''$	Di ff. A.'	Di ff. A."
7	50	46			17	48	14			23	8	47		
7	54	33	3	47	17	50	55	2	41	23	9	32	0	45
7	58	20	3	47	17	53	36	2	41	23	10	16	0	44
8	2	7	3	47	17	56	16	2	40	23	10	59	0	43
8	5	54	3	47	17	58	56	2	40	23	11	42	0	42
8	9	40	3	46	18	1	35	2	39	23	12	24	0	42
8	13	26	3	46	18	4	14	2	39	23	13	5	0	41
8	17	12	3	46	18	6	52	2	38	23	13	45	0	40
8	20	58	3	46	18	9	30	2	38	23	14	24	0	39
8	24	43	3	45	18	12	8	2	38	23	15	3	0	39
8	28	28	3	45	18	14	45	2	37	23	15	41	0	38
8	32	13	3	45	18	17	21	2	36	23	16	19	0	38
8	35	58	3	45	18	19	57	2	36	23	16	56	0	37
8	39	42	3	45	18	22	32	2	35	23	17	32	0	36
8	43	26	3	44	18	25	6	2	34	23	18	7	0	35
8	47	10	3	44	18	27	40	2	34	23	18	41	0	34
8	50	54	3	44	18	30	13	2	33	23	19	15	0	34
8	54	37	3	43	18	32	46	2	33	23	19	48	0	33
8	58	20	3	43	18	35	18	2	32	23	20	20	0	32
9	2	3	3	43	18	37	50	2	32	23	20	52	0	32
9	5	46	3	43	18	40	21	2	31	23	21	23	0	31
9	9	28	3	42	18	42	52	2	31	23	21	53	0	30
9	13	10	3	42	18	45	22	2	30	23	22	22	0	29
9	16	52	3	42	18	47	52	2	30	23	22	50	0	28
9	20	34	3	42	18	50	21	2	29	23	23	18	0	28
9	24	16	3	42	18	52	50	2	29	23	23	45	0	27
9	27	58	3	41	18	55	18	2	28	23	24	11	0	26

$\Upsilon/\underline{\Omega}$ P.	$\Upsilon/\underline{\Omega}'$	$\Upsilon/\underline{\Omega}''$	Di ff. A. '	Di ff. A. ''	$\vartheta/\mathfrak{M}$ P.	$\vartheta/\mathfrak{M}'$	$\vartheta/\mathfrak{M}''$	Di ff. A. '	Di ff. A. ''	$\Pi/\mathfrak{X}$ P.	$\Pi/\mathfrak{X}'$	$\Pi/\mathfrak{X}''$	Di ff. A. '	Di ff. A. ''
9	31	39	3	41	18	57	45	2	27	23	24	36	0	25
9	35	20	3	41	19	0	12	2	27	23	25	1	0	24
9	39	1	3	40	19	2	38	2	26	23	25	25	0	24
9	42	41			19	5	4	2	26	23	25	48	0	23

Foot signs: $\mathfrak{X}/\mathfrak{M}$ (under $\Upsilon/\underline{\Omega}$), $\mathfrak{X}/\mathfrak{M}$ (under $\vartheta/\mathfrak{M}$), $\mathfrak{X}/\mathfrak{X}$ (under $\Pi/\mathfrak{X}$); foot-difference columns labelled Diff. S.

Page 86 — head heading: GRADVVM 23. MINVT: 31. SECVND: 30.

(This is the heading stating the assumed obliquity of the ecliptic: 23 degrees, 31 minutes, 30 seconds.)

$\Upsilon/\underline{\Omega}$ P.	$\Upsilon/\underline{\Omega}'$	$\Upsilon/\underline{\Omega}''$	Di ff. A. '	Di ff. A. ''	$\vartheta/\mathfrak{M}$ P.	$\vartheta/\mathfrak{M}'$	$\vartheta/\mathfrak{M}''$	Di ff. A. '	Di ff. A. ''	$\Pi/\mathfrak{X}$ P.	$\Pi/\mathfrak{X}'$	$\Pi/\mathfrak{X}''$	Di ff. A. '	Di ff. A. ''
9	42	41			19	5	4			23	25	48		
9	46	21	3	40	19	7	29	2	25	23	26	10	0	22
9	50	1	3	40	19	9	54	2	25	23	26	31	0	21
9	53	41	3	40	19	12	18	2	24	23	26	52	0	21
9	57	20	3	39	19	14	41	2	23	23	27	12	0	20
10	0	59	3	39	19	17	4	2	23	23	27	32	0	20
10	4	38	3	39	19	19	26	2	22	23	27	51	0	19
10	8	16	3	38	19	21	48	2	22	23	28	9	0	18
10	11	54	3	38	19	24	9	2	21	23	28	26	0	18
10	15	32	3	38	19	26	29	2	20	23	28	42	0	17
10	19	10	3	38	19	28	49	2	20	23	28	58	0	16
10	22	47	3	37	19	31	8	2	19	23	29	13	0	15
10	26	24	3	37	19	33	27	2	19	23	29	27	0	14
10	30	1	3	37	19	35	45	2	18	23	29	40	0	13
10	33	38	3	37	19	38	3	2	18	23	29	52	0	12
10	37	14	3	36	19	40	20	2	17	23	30	4	0	12
10	40	50	3	36	19	42	36	2	16	23	30	15	0	11

♈/ ♈ P.	♈/ ♈'	♈/ ♈''	Di ff. A.'	Di ff. A. ''	♉/ ♉ P.	♉/ ♉'	♉/ ♉''	Di ff. A.'	Di ff. A. ''	♊/ ♊ P.	♊/ ♊'	♊/ ♊''	Di ff. A.'	Di ff. A. ''
10	44	26	3	36	19	44	52	2	16	23	30	25	0	11
10	48	2	3	35	19	47	7	2	15	23	30	35	0	10
10	51	37	3	35	19	49	22	2	14	23	30	44	0	9
10	55	12	3	34	19	51	36	2	14	23	30	52	0	8
10	58	46	3	34	19	53	50	2	13	23	30	59	0	7
11	2	20	3	33	19	56	3	2	12	23	31	6	0	7
11	5	53	3	34	19	58	15	2	11	23	31	12	0	6
11	9	27	3	33	20	0	26	2	11	23	31	17	0	5
11	13	0	3	33	20	2	37	2	10	23	31	21	0	4
11	16	33	3	33	20	4	47	2	10	23	31	24	0	3
11	20	6	3	32	20	6	57	2	9	23	31	26	0	2
11	23	38	3	32	20	9	6	2	8	23	31	28	0	2
11	27	10	3	32	20	11	14	2	8	23	31	29	0	1
11	30	42			20	13	22			23	31	30		

Foot signs: ♈/♈, ♉/♉, ♊/♊; foot-difference columns labelled Diff. S.

At argument 30°0' the ♊/♊ block reaches **23° 31' 30''**, the maximum ecliptic declination — exactly equal to the assumed obliquity of the ecliptic (23°31'30''), at the summer solstice. This completes the Table of the Ecliptic Declination.

Table of Right Ascensions, for Each Degree of the Ecliptic

Page 87 — heading: TABVLA ASCENSIONVM RECTARVM ("Table of Right Ascensions")

A new table begins here: the **right ascension** [ascensio recta] corresponding to each whole degree of ecliptic longitude. The argument column (GRAD. Eclipt. = degrees of the ecliptic, 0–30) runs at the left and repeats at the right. For each of the first three signs — ♈ (Aries), ♉ (Taurus), ♊ (Gemini) — the right ascension is given in degrees (P.), minutes ('), and seconds (''), each followed by its first-difference column [Differ.].

GRA D. Eclip t.	♈					♉					♊					G R A D
	P .	♈ '	♈ "	Diff er.'	Diff er."	P .	♉ '	♉ "	Diff er.'	Diff er."	P .	♊ '	♊ "	Diff er.'	Diff er."	D .
0	0	0	0			2 7	5 3	4 3			5 7	4 8	7			0
1	0	5 5	1	55	1	2 8	5 1	5	57	22	5 8	5 0	4 0	62	33	1
2	1	5 0	2	55	1	2 9	4 8	3 6	57	31	5 9	5 3	2 3	62	45	2
3	2	4 5	4	55	2	3 0	4 6	1 6	57	40	6 0	5 6	1 6	62	53	3
4	3	4 0	7	55	3	3 1	4 4	5	57	49	6 1	5 9	1 9	63	3	4
5	4	3 5	1 1	55	4	3 2	4 2	3	57	58	6 3	2	3 2	63	13	5
6	5	3 0	1 7	55	6	3 3	4 0	1 1	58	8	6 4	5	5 5	63	23	6
7	6	2 5	2 5	55	8	3 4	3 8	2 9	58	18	6 5	9	2 7	63	32	7
8	7	2 0	3 5	55	10	3 5	3 6	5 7	58	28	6 6	1 3	8	63	41	8
9	8	1 5	4 7	55	12	3 6	3 5	3 5	58	38	6 7	1 6	5 7	63	49	9
10	9	1 1	2	55	15	3 7	3 4	2 3	58	48	6 8	2 0	5 4	63	57	1 0
11	1 0	6	2 0	55	18	3 8	3 3	2 2	58	59	6 9	2 4	5 9	64	5	1 1
12	1 1	1	4 1	55	21	3 9	3 2	3 2	59	10	7 0	2 9	1 2	64	13	1 2
13	1 1	5 7	6	55	25	4 0	3 1	5 2	59	20	7 1	3 3	3 2	64	20	1 3
14	1 2	5 2	3 5	55	29	4 1	3 1	2 2	59	30	7 2	3 7	5 9	64	27	1 4

GRA D. Eclip t.	♈					♉					♊					G R A D
	P .	♈ '	♈ "	Diff er. '	Diff er. "	P .	♉ '	♉ "	Diff er. '	Diff er. "	P .	♊ '	♊ "	Diff er. '	Diff er. "	D .
15	1 3	4 8	9	55	34	4 2	3 1	3	59	41	7 3	4 2	3 3	64	34	1 5
16	1 4	4 3	4 8	55	39	4 3	3 0	5	59	52	7 4	4 7	1 3	64	40	1 6
17	1 5	3 9	3 2	55	44	4 4	3 0	5 8	60	3	7 5	5 1	5 9	64	46	1 7
18	1 6	3 5	2 1	55	49	4 5	3 1	1	60	13	7 6	5 6	5 1	64	52	1 8
19	1 7	3 1	1 6	55	55	4 6	3 1	3 6	60	25	7 8	1	4 7	64	56	1 9
20	1 8	2 7	1 7	56	1	4 7	3 2	1 2	60	36	7 9	6	4 8	65	1	2 0
21	1 9	2 3	2 4	56	7	4 8	3 2	5 9	60	47	8 0	1 1	5 4	65	6	2 1
22	2 0	1 9	3 7	56	13	4 9	3 3	5 7	60	58	8 1	1 7	4	65	10	2 2
23	2 1	1 5	5 7	56	20	5 0	3 5	6	61	9	8 2	2 2	1 8	65	14	2 3
24	2 2	1 2	2 4	56	27	5 1	3 6	2 5	61	19	8 3	2 7	3 5	65	17	2 4
25	2 3	8	5 8	56	34	5 2	3 7	5 5	61	30	8 4	3 2	5 5	65	20	2 5
26	2 4	5	3 9	56	41	5 3	3 9	3 6	61	41	8 5	3 8	1 8	65	23	2 6
27	2 5	2	2 8	56	49	5 4	4 1	2 8	61	52	8 6	4 3	4 2	65	24	2 7
28	2 5	5 9	2 5	56	57	5 5	4 3	3 1	62	3	8 7	4 9	7	65	25	2 8
29	2 6	5 6	3 0	57	5	5 6	4 5	4 4	62	13	8 8	5 4	3 3	65	26	2 9
30	2	5	4	57	13	5	4	7	62	23	9	0	0	65	27	3

GRA	♊					♋					♌					G
D.																R
Eclip	P	♊	♊	Diff	Diff	P	♋	♋	Diff	Diff	P	♌	♌	Diff	Diff	A
t.	.	'	"	er.'	er."	.	'	"	er.'	er."	.	'	"	er.'	er."	D
	7	3	3			7	8				0					0

Page 88 — heading: AD SINGVLOS GRADVS ECLIPTICAE ("...for each degree of the ecliptic")

Continuation of the Table of Right Ascensions for the next three signs — ♋ (Cancer, here marked with the ♋/"69" symbol), ♌ (Leo), ♍ (Virgo) — in the same degrees/minutes/seconds + first-difference layout.

GRA	♋					♌					♍					G
D.																R
Eclip	P	♋	♋	Diff	Diff	P	♌	♌	Diff	Diff	P	♍		Diff	Diff	D
t.	.	'	"	er.'	er."	.	'	"	er.'	er."	.	'	♍"	er.'	er."	.
0	9	0	0			1	1	5			1	6	18			0
	0					2	1	3			5					
						2					2					
1	9	5	2	65	27	1	1	1	62	23	1	3	31	57	13	1
	1		7			2	4	6			5					
						3					3					
2	9	1	5	65	26	1	1	2	62	13	1	0	36	57	5	2
	2	0	3			2	6	9			5					
						4					4					
3	9	1	1	65	25	1	1	3	62	3	1	5	33	56	57	3
	3	6	8			2	8	2			5	7				
						5					4					
4	9	2	4	65	24	1	2	2	61	52	1	5	22	56	49	4
	4	1	2			2	0	4			5	4				
						6					5					
5	9	2	5	65	23	1	2	5	61	41	1	5	3	56	41	5
	5	7				2	2				5	1				
						7					6					

GRA D. Eclip t.	☾					♈					♏					G R A D
	P .	☾ '	☾ "	Diff er.'	Diff er."	P .	♈ '	♈ "	Diff er.'	Diff er."	P .	♏ '	♏ "	Diff er.'	Diff er."	.
6	9 6	3 2	2 5	65	20	1 2 8	2 3	3 5	61	30	1 5 7	4 7	37	56	34	6
7	9 7	3 7	4 2	65	17	1 2 9	2 4	5 4	61	19	1 5 8	4 4	4	56	27	7
8	9 8	4 2	5 6	65	14	1 3 0	2 5	3	61	9	1 5 9	4 0	23	56	19	8
9	9 9	4 8	6	65	10	1 3 1	2 7	1	60	58	1 6 0	3 6	36	56	13	9
10	1 0 0	5 3	1 2	65	6	1 3 2	2 7	4 8	60	47	1 6 1	3 2	43	56	7	1 0
11	1 0 1	5 8	1 3	65	1	1 3 3	2 8	2 4	60	36	1 6 2	2 8	44	56	1	1 1
12	1 0 3	3	9	64	56	1 3 4	2 8	4 9	60	25	1 6 3	2 4	39	55	55	1 2
13	1 0 4	8	1	64	52	1 3 5	2 9	2	60	13	1 6 4	2 0	28	55	49	1 3
14	1 0 5	1 2	4 7	64	46	1 3 6	2 9	5	60	2	1 6 5	1 6	12	55	44	1 4
15	1 0 6	1 7	2 7	64	40	1 3 7	2 8	5 7	59	52	1 6 6	1 1	51	55	39	1 5
16	1 0	2	1	64	34	1 3	2	3	59	41	1 6	7	25	55	34	1

GRA D. Eclip t.	♄					♂					♃					G R A D
	P .	♄ '	♄ "	Diff er.'	Diff er."	P .	♂ '	♂ "	Diff er.'	Diff er."	P .	♃ '	♃ "	Diff er.'	Diff er."	.
	7	2				8	8	8			7					6
17	1 0 8	2 6	2 8	64	27	1 3 9	2 8	8	59	30	1 6 8	2	54	55	29	1 7
18	1 0 9	3 0	4 8	64	20	1 4 0	2 7	2 8	59	20	1 6 8	5 8	19	55	25	1 8
19	1 1 0	3 5	1	64	13	1 4 1	2 6	3 8	59	10	1 6 9	5 3	40	55	21	1 9
20	1 1 1	3 9	6	64	5	1 4 2	2 5	3 7	58	59	1 7 0	4 8	58	55	18	2 0
21	1 1 2	4 3	4	63	58	1 4 3	2 4	2 5	58	48	1 7 1	4 4	13	55	15	2 1
22	1 1 3	4 6	5 3	63	49	1 4 4	2 3	3	58	38	1 7 2	3 9	125 [recte: 25?]	55	12	2 2
23	1 1 4	5 0	3 4	63	41	1 4 5	2 1	3 1	58	28	1 7 3	3 4	35	55	10	2 3
24	1 1 5	5 4	6	63	32	1 4 6	1 9	4 9	58	18	1 7 4	2 9	43	55	8	2 4
25	1 1 6	5 7	2 9	63	23	1 4 7	1 7	5 7	58	8	1 7 5	2 4	49	55	6	2 5
26	1 1 8	0	4 2	63	13	1 4 8	1 5	5 5	57	58	1 7 6	1 9	53	55	4	2 6

GRA	♎					♏					♐					G
D.																R
Eclip	P	♎	♎	Diff	Diff	P	♏	♏	Diff	Diff	P	♐	♐	Diff	Diff	D
t.	.	'	"	er.'	er."	.	'	"	er.'	er."	.	'	♐"	er.'	er."	.
27	1	3	4	63	3	1	1	4	57	49	1	1	56	55	3	2
	1		5			4	3	4			7	4				7
	9					9					7					
28	1	6	3	62	53	1	1	2	57	40	1	9	58	55	2	2
	2		8			5	1	4			7					8
	0					0					8					
29	1	9	2	62	42	1	8	5	57	31	1	4	59	55	1	2
	2		0			5		5			7					9
	1					1					9					
30	1	1	5	62	33	1	6	1	57	23	1	0	0	55	1	3
	2	1	3			5		8			8					0
	2					2					0					

The right-edge GRAD. column repeats the ecliptic-degree argument (0–30).

Table of Right Ascensions (continued)

TABLE OF RIGHT ASCENSIONS, PRESUPPOSING THE GREATEST DECLINATION

The table continues the right ascension (in degrees, minutes, seconds) for each degree of the ecliptic. This page covers the signs ♎ (Libra), ♏ (Scorpio), and ♐ (Sagittarius), with the per-degree first-difference columns (*Differ.*). The left and right margins both carry the degree count (GRAD.), 0–30.

The full printed heading running across the top of this opening reads:

PRAESVPPONENS DECLINATIONEM MAXIMAM, QVAE HOC AEVO EST PART.

23. MINVT. 31½. ("presupposing the greatest declination, which in this age is 23 degrees 31½ minutes") — the first half printed on p. 89, the second half on p. 90.

G R A D .	$\underline{P.}$	$\underline{'}$	$\underline{''}$	Diff er $'$	Diff er $''$	$\mathfrak{M}$ P.	$\mathfrak{M}$ $'$	$\mathfrak{M}$ $''$	Diff er $'$	Diff er $''$	$\times^{\nearrow}$ P.	$\times^{\nearrow}$ $'$	$\times^{\nearrow}$ $''$	Diff er $'$	Diff er $''$	G R A D .
0	1 8 0	0	0			2 0 7	53	43			2 3 7	48	7			0
1	1 8 0	55	1	55	1	2 0 8	51	5	57	22	2 3 8	50	40	62	33	1
2	1 8 1	50	2	55	1	2 0 9	48	36	57	31	2 3 9	53	23	62	43	2
3	1 8 2	45	4	55	2	2 1 0	46	16	57	40	2 4 0	56	16	62	53	3
4	1 8 3	40	7	55	3	2 1 1	44	5	57	49	2 4 1	59	19	63	3	4
5	1 8 4	35	11	55	4	2 1 2	42	3	57	58	2 4 3	2	32	63	13	5
6	1 8 5	30	17	55	6	2 1 3	40	11	58	8	2 4 4	5	55	63	23	6
7	1 8 6	25	25	55	8	2 1 4	38	29	58	18	2 4 5	9	27	63	32	7
8	1 8 7	20	35	55	10	2 1 5	36	57	58	28	2 4 6	13	8	63	41	8
9	1 8 8	15	47	55	12	2 1 6	35	35	58	38	2 4 7	16	57	63	49	9
10	1 8	11	2	55	15	2 1	34	23	58	48	2 4	20	54	63	57	1

G R A D .	$\underline{n}$ P.	$\underline{n}$ '	$\underline{n}$ "	Diff er'	Diff er''	$\mathfrak{M}$ P.	$\mathfrak{M}$ '	$\mathfrak{M}$ "	Diff er'	Diff er''	$\times$ P.	$\times$ '	$\times$ "	Diff er'	Diff er''	G R A D .
	9					7					8					0
1 1 1	1 9 0	6	20	55	18	2 1 8	33	22	58	59	2 4 9	24	59	64	5	1 1 1
1 2 1	1 9 1	1	41	55	21	2 1 9	32	32	59	10	2 5 0	29	12	64	13	1 2 1
1 3 1	1 9 1	57	6	55	25	2 2 0	31	52	59	20	2 5 1	33	32	64	20	1 3 1
1 4 1	1 9 2	52	35	55	29	2 2 1	31	22	59	30	2 5 2	37	59	64	27	1 4 1
1 5 1	1 9 3	48	9	55	34	2 2 2	31	3	59	41	2 5 3	42	33	64	34	1 5 1
1 6 1	1 9 4	43	48	55	39	2 2 3	30	55	59	52	2 5 4	47	13	64	40	1 6 1
1 7 1	1 9 5	39	32	55	44	2 2 4	30	58	60	3	2 5 5	51	59	64	46	1 7 1
1 8 1	1 9 6	35	21	55	49	2 2 5	31	11	60	13	2 5 6	56	51	64	52	1 8 1
1 9 1	1 9 7	31	16	55	55	2 2 6	31	36	60	25	2 5 8	1	47	64	56	1 9 1
2 0 1	1 9 8	27	17	56	1	2 2 7	32	12	60	36	2 5 9	6	48	65	1	2 0 1

G R A D .	$\underline{\alpha}$ P.	$\underline{\alpha}$ '	$\underline{\alpha}$ "	Diff er'	Diff er"	μ P.	μ '	μ "	Diff er'	Diff er"	$\times$ P.	$\times$ '	$\times$ "	Diff er'	Diff er"	G R A D .
2 1	1 9 9	23	24	56	7	2 2 8	32	59	60	47	2 6 0	11	54	65	6	2 1
2 2	2 0 0	19	37	56	13	2 2 9	33	57	60	58	2 6 1	17	4	65	10	2 2
2 3	2 0 1	15	57	56	20	2 3 0	35	6	61	9	2 6 2	22	18	65	14	2 3
2 4	2 0 2	12	24	56	27	2 3 1	36	25	61	19	2 6 3	27	35	65	17	2 4
2 5	2 0 3	8	58	56	34	2 3 2	37	55	61	30	2 6 4	32	55	65	20	2 5
2 6	2 0 4	5	39	56	41	2 3 3	39	36	61	41	2 6 5	38	18	65	23	2 6
2 7	2 0 5	2	28	56	49	2 3 4	41	28	61	52	2 6 6	43	42	65	24	2 7
2 8	2 0 5	59	25	56	57	2 3 5	43	31	62	3	2 6 7	49	7	65	25	2 8
2 9	2 0 6	56	30	57	5	2 3 6	45	44	62	13	2 6 8	54	33	65	25	2 9
3 0	2 0 7	53	43	57	13	2 3 7	48	7	62	23	2 7 0	0	0 [?]	65	27	3 0

TABLE OF RIGHT ASCENSIONS (continued)

This page covers the signs ♑ (Capricorn), ♒ (Aquarius), and ♓ (Pisces), completing the right-ascension table at 360°. Heading: **QVAE HOC AEVO EST PART. 23. MINVT. 31½.** (the continuation of the heading begun on p. 89).

G																G
R	♊		♋								♌				R	
A															A	
D	P	♊		Diff	Diff	P	♋	♋	Diff	Diff	P	♌	♌	Diff	Diff	D
.	.	'	♊''	er'	er''	.	'	''	er'	er''	.	'	''	er'	er''	.
0	2	0	0			3	1	5			3	6	1			0
	7					0	1	3			3		8			
	0					2					2					
1	2	5	27	65	27	3	1	1	62	23	3	3	3	57	13	1
	7					0	4	6			3		1			
	1					3					3					
2	2	1	53	65	26	3	1	2	62	13	3	0	3	57	5	2
	7	0				0	6	9			3		6			
	2					4					4					
3	2	1	18	65	25	3	1	3	62	3	3	5	3	56	57	3
	7	6				0	8	2			3	7	3			
	3					5					4					
4	2	2	42	65	24	3	2	2	61	52	3	5	2	56	49	4
	7	1				0	0	4			3	4	2			
	4					6					5					
5	2	2	5	65	23	3	2	5	61	41	3	5	3	56	41	5
	7	7				0	2				3	1				
	5					7					6					
6	2	3	25	65	20	3	2	3	61	30	3	4	3	56	34	6
	7	2				0	3	5			3	7	7			
	6					8					7					
7	2	3	42	65	17	3	2	5	61	19	3	4	4	56	27	7
	7	7				0	4	4			3	4				
	7					9					8					

G R A D .	у ₀			≈							✕				G R A D .	
P .	у ₀ '	у ₀ ''		Diff er'	Diff er''	P .	≈ '	≈ ''	Diff er'	Diff er''	P .	✕ '	✕ ''	Diff er'	Diff er''	
8	2	4	56	65	14	3	2	3	61	9	3	4	2	56	19	8
	7	2				1	6				3	0	3			
	8					0					9					
9	2	4	6	65	10	3	2	1	60	58	3	3	3	56	13	9
	7	8				1	7				4	6	6			
	9					1					0					
1	2	5	12	65	6	3	2	4	60	47	3	3	4	56	7	1
0	8	3				1	7	8			4	2	3			0
	0					2					1					
1	2	5	13	65	1	3	2	2	60	36	3	2	4	56	1	1
1	8	8				1	8	4			4	8	4			1
	1					3					2					
1	2	3	9	64	56	3	2	4	60	25	3	2	3	55	55	1
2	8					1	8	9			4	4	9			2
	3					4					3					
1	2	8	1	64	52	3	2	2	60	13	3	2	2	55	49	1
3	8					1	9				4	0	8			3
	4					5					4					
1	2	1	47	64	46	3	2	5	60	3	3	1	1	55	44	1
4	8	2				1	9				4	6	2			4
	5					6					5					
1	2	1	27	64	40	3	2	5	59	52	3	1	5	55	39	1
5	8	7				1	8	7			4	1	1			5
	6					7					6					
1	2	2	1	64	34	3	2	3	59	41	3	7	2	55	34	1
6	8	2				1	8	8			4		5			6
	7					8					7					
1	2	2	28	64	27	3	2	8	59	30	3	2	5	55	29	1
7	8	6				1	8				4		4			7
	8					9					8					
1	2	3	48	64	20	3	2	2	59	20	3	5	1	55	25	1
8	8					2					4					

G R A D .	у ₀			≈									✕			G R A D .
P .	у ₀ '	у ₀ "		Diff er'	Diff er"	P .	≈ '	≈ "	Diff er'	Diff er"	P .	✕ '	✕ "	Diff er'	Diff er"	
	9	0				0	7	8			8	8	9			8
1 9	2 9	3 5	1	64	13	3 2 1	2 6	3 8	59	10	3 4 9	5 3 0	4 0	55	21	1 9
2 0	2 9	3 9	6	64	5	3 2 2	2 5	3 7	58	59	3 5 0	4 8 0	5 8	55	18	2 0
2 1	2 9	4 3	4	63	58	3 2 3	2 4	2 5	58	48	3 5 1	4 4 0	1 3	55	15	2 1
2 2	2 9	4 6	53	63	49	3 2 4	2 3	3	58	38	3 5 2	3 9 0	2 5	55	12	2 2
2 3	2 9	5 0	34	63	41	3 2 5	2 1	3 1	58	28	3 5 3	3 4 0	3 5	55	10	2 3
2 4	2 9	5 4	6	63	32	3 2 6	1 9	4 9	58	18	3 5 4	2 9 0	4 3	55	8	2 4
2 5	2 9	5 7	29	63	23	3 2 7	1 7	5 7	58	8	3 5 5	2 4 0	4 9	55	6	2 5
2 6	2 9	0	42	63	13	3 2 8	1 5	5 5	57	58	3 5 6	1 9 0	5 3	55	4	2 6
2 7	2 9	3	45	63	3	3 2 9	1 3	4 4	57	49	3 5 7	1 4 0	5 6	55	3	2 7
2 8	3 0	6	38	62	53	3 3 0	1 1	2 4	57	40	3 5 8	9 0	5 8	55	2	2 8

G																G		
R	γ ₀											≍					⋈	R
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D	P	γ ₀		Diff	Diff	P	≍	≍	Diff	Diff	P	⋈	⋈	Diff	Diff	D		
.	.	'	γ ₀ ''	er'	er''	.	'	''	er'	er''	.	'	''	er'	er''	.		
2	3	9	120	62	42	3	8	5	57	31	3	4	5	55	1	2		
9	0		[recte:			3		5			5		9			9		
	1		?]			1					9							
3	3	1	53	62	33	3	6	1	57	23	3	0	0	55	1	3		
0	0	1				3		8			6					0		
	2					2					0							

ANNOTATION ON THE FOUNDATIONS, CONSTRUCTION, AND USE OF THE PRECEDING TABLES

Now that I have set out the tables in this manner, as I promised, it seems useful to append an account of how they were composed and how they are to be used, so that their foundations and proper application may be understood more correctly. First, then, I shall explain the principles of the refractions and the table that goes with them; after that I shall set out the rest in the order in which they follow.

On the Refractions of the Sun, and the Table of Them.

When, not a few years ago, I had turned my mind to the consideration and observation of the heavenly bodies — long before larger and more exact instruments were at hand — I had a less well-tested understanding of the refractions that creep into the apparent positions of these bodies, especially where they are seen nearer the horizon. Afterwards, however, once I had built larger instruments that displayed each detail with precision, I noticed these refractions clearly enough; and indeed I came to recognize their causes, already in some way examined by the writers on optics, not unwillingly. Those writers (among whom the chief are Alhazen [Ibn al-Haytham] and Vitellio [Witelo]) say that whenever a visible object is viewed through media of differing transparency [*diaphanitas*], its appearance reaches the eye refracted. They hold that the transparency of the aether differs from that of the air and of the element of fire (which they vainly assign to the concave sphere of the Moon), being rarer and purer.

Although in this matter they may seem to propose nothing wholly at variance with the truth, nevertheless — because, following the long-accepted authority of

the ancient philosophers, and especially of Aristotle [Aristoteles], they suppose the heavens to consist of some solid transparent substance and to differ perceptibly from the transparency of the air — they exaggerate this occasion too far and have increased the refractions themselves beyond what is just. And indeed the experiments that Alhazen adduces (book 7, prop. 15 and following), and that his imitator Vitellio adduces (book 10, prop. 49 and 50), they carry out by means of an armillary instrument; and although these would be easy enough to put into execution as they describe them, yet (because they may be carried out by themselves, or perhaps by some other) — given the precision required, and the most exact conformation in every respect of magnitude and instrument that is demanded — I can scarcely persuade myself that they were performed with the excellence they suppose, so that their conclusion barely holds. For if it were so evident that there is a discrepancy between the transparency of the aether and that of the air — such as they admit — then refractions would surely be perceptible right up to nearly the zenith itself; and that does not at all correspond to plain experience. For their own measure of these refractions, at a somewhat higher position, becomes so attenuated that around the middle of the quadrant they are as small as possible to perceive, even in the case of the Sun. The most powerful and truer cause of refractions, therefore, lies in the vapors perpetually overhanging the surface of the Earth, which render the air nearest to us a little denser, and less transparent, than its upper portion is.

From this it also follows that those refractions are most strongly encountered by the sight near the horizon, while in a higher position they are gradually attenuated. And although certain of the more recent writers deduce from this only the cause of refractions — claiming that the nature and material of the heavens and of the air are entirely the same, namely that the heavens, in which the stars are perpetually carried round, are nothing other than the elemental and animating air itself, supposed to be free of terrestrial vapors — I have no doubt that on this point, for sound reasons, I by no means agree with their opinion, as I shall discuss more fully elsewhere. For although the heavens are most fluid and most rarefied, and are not compacted of any real orbs (which so many philosophizing men through so many ages have vainly and credulously persuaded themselves of), as I shall sufficiently show toward the end of this work from the very comets that complete their courses within them, nevertheless I would not on that account readily concede that the heavens are of one and the same kind and substance with the elemental air (which Aristotle's school, placing the element of fire beneath the Moon, has so long and so fancifully imagined) — nor that the slightness of refraction in the Sun and the stars, if it convinces of nothing else besides, proves this. For the discrepancy that arises from the

difference in transparency between the aether and the air may well be so very small, and in no way as great as the opticians supposed — indeed so slight that it scarcely falls within the senses. It is consistent, after all, that the air, as it approaches the revolutions of the Moon, is successively rendered so much subtler in purity that it differs nothing, or as little as possible, from the transparency of the aether.

Moreover, even if it were wholly the same, and refractions were to occur with no regard to any diversification of the transparency of the aether and the air, it still would not on that account be sufficiently inferred that the matter of the heavens is altogether the same as the elemental and sublunary air — as the first, so far as I know, IOHANNES PENA the Frenchman [Jean Pena] put forward, and as certain of the moderns also do not hesitate to affirm. Among them is that most learned man, solidly versed in astronomical matters, the most illustrious Christophorus Rothmannus [Christoph Rothmann], mathematician to the most illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse], with whom I too have several times exchanged letters on this very subject. Yet because the refractions vanish so quickly and do not extend to the zenith, he persists in the opinion he has adopted and cannot be drawn away from it. But truly, because the air — especially the upper air — can be the same, given that there is an identity and, as it were, a homogeneity of transparency with that of the heavens, so that for that reason refractions would scarcely be perceptibly apparent in respect of the differing transparencies of the aether and the air, and would be observed not to reach the zenith at all — this reasoning is less valid, since the very great distance of the heavens also withdraws the minute refractions from view. Nor, again, does it follow well enough that two bodies of the same and similar transparency are also of one and the same substance and matter. But because I discuss these matters more fully elsewhere, lest I seem to linger too long over them in this place, I shall now proceed to the business at hand: I shall show how the refractions themselves, wherever they take their origin — and especially in the Sun — are to be investigated by means of the heavens, where I shall propose two methods of experimenting on this very thing, using different instruments.

The first will be by means of a large azimuthal quadrant [Quadrans Azimuthalis], one that displays the individual minutes together with their fractional subdivisions, and that, conveniently mounted in a vertical plane and free to be turned in any direction, shows the azimuths themselves with no uncertainty at all. As for how this same result may be achieved conveniently and exactly even on larger machines — which in other respects raise no small obstacles by their sheer mass — I shall expound it fully in that book, God willing, in which I shall

treat of the construction and use of astronomical instruments and of this mechanical art [Mechanica].

Therefore, around the summer tropic, when the Sun is at its highest at noon — and especially on the very day of the solstice, when its declination varies imperceptibly — provided the air is calm on every side and reasonably clear, both near the horizon on either part and toward the meridian and the places between, then by means of a quadrant instrument of this kind, properly set up and with the azimuths accurately found from the line of the meridian, the Sun should be observed from its rising onward at each single degree of altitude. Together with it the quadrant should be turned about, and one should note which degree of the horizon, with its minutes, it grazes at each elevation — doing this until the Sun is raised to its highest position at the meridian, and afterwards keeping it up in the same way all the way to its setting. For in this manner it will not be hidden what apparent altitude the Sun occupies at however great a remove from the meridian. Accordingly we shall investigate its parallax by the following reasoning. Since at the meridian the Sun's altitude is given as imperceptibly liable to refraction, and since by the correction for parallax its true declination is known — that is, once the inclination of the equator at the place of observation has first been carefully examined — from this, at the places of the individual azimuths, with the altitudes corresponding to them having been found, we shall inquire, by way of the appropriate declination, what altitude in truth belongs to it at such a distance from the meridian; and this will be accomplished without difficulty by the following demonstration.

Diagram. In the assigned figure, B is the pole of the horizon; A the [pole] of the equator; CBAE the meridian; CDE represents the horizon; and the quadrant BFGD [represents] the vertical circle passing through both positions of the Sun — G the true [position] and F the refracted one. To these positions there are also drawn, from the pole A of the equator, the two arcs AG and AF, as is sufficiently plain from the drawing itself to anyone who understands it. The figure is a semicircle on the horizontal base CDE, with B at the apex and A set toward the right of the apex; within it the points F, H, and G cluster left of center, just above the base point D.

- B (apex): pole of the horizon [Polus Horizontis]
- A (upper right, near apex): pole of the equator [Polus Æquatoris]
- C (lower left, base): left end of meridian/horizon
- D (base, center): foot of the vertical circle
- E (lower right, base): right end of horizon

- F (left of center): refracted position of the Sun [Refractum]
- G (below F): true position of the Sun [Verum]
- H (right of F): intersection point on the vertical circle

Since, then, in the triangle BAG, the side BA is given as the complement of the pole's altitude to 90, and GA the complement of the Sun's true declination, while the angle GBA is the complement of the azimuth to 180 — that is, to the semicircle reckoned from the meridian — and [since these are] known by observation: therefore, since in the said triangle two sides together with one angle hold good, the third side BG will not be hidden, [namely] the complement of the Sun's true altitude in that azimuth. And so GD itself is that true altitude. But by observation FD was given, the Sun's apparent elevation; to this, however, the parallax arising at a comparable elevation should be added (because this inclines the Sun toward the horizon, and somewhat corrects the refraction). In this way we shall recognize the elevation of the Sun apparent at F, if it were wholly free of parallax. By taking away from this the true altitude found by computation at the same azimuth, the refraction sought, FG, will be obtained.

The second method is carried out as follows: by means of a very large armillary instrument [Instrumentum Armillare] — such as the one we have at hand, in which there is a revolving armilla that measures the declinations, ten feet in diameter — whose axis at each end looks most exactly to the poles of the world, with a cylinder fixed at its middle and corresponding sighting-vanes [Pinnacidia] fitted around the circumference (just as I shall give a fuller account of the construction of this and of the other instruments in the book mentioned above). Let the Sun's declination be observed around the summer solstice, and likewise from its rising in the meridian and then all the way to its setting; at a definite altitude, which everywhere should be noted with the help of another instrument — a quadrant, namely, or the like, that measures the Sun's elevation carefully. From the apparent declination thus known at a known elevation, the refraction in the vertical circle will at once be established.

For, keeping the earlier figure, since here in the triangle BAF there are given the three sides — BA the complement of the pole's altitude, AF the complement of the observed elevation, and BF [recte: BG] the complement of its declination obtained by the armilla, which corresponds to such an altitude — therefore, with three sides given, the angle BAF will not be unknown. Hence in the triangle AGF, from the two known sides AF, the complement of the apparent declination, AG the complement of the same true declination, and the angle GFA from the complement of the angle BFA just found relative to the semicircle — since two

sides with one angle hold good, the third FG will not be hidden, representing the refraction in the vertical circle. To this, nevertheless, the parallax must be added, because it makes the Sun lower; for without it the Sun would appear higher through refraction, and on that account the refraction would be greater.

Or we shall obtain the same result thus. Since in the triangle BAF, as I said, three sides are given, the angle at B will be established. Then in the triangle BAG, since the two sides are known — BA the complement of the pole's altitude, AG the complement of the true declination — and the angle at B has now become known, here too from the two given sides together with one angle the remaining side BG will be known, the complement of the true altitude; and if from this BF, the complement of the apparent altitude, be taken away, there will remain FG the refraction, which was sought — to be corrected, however, as before, by the addition of the parallax. It will be possible, moreover, to accomplish this same thing more compendiously, in this manner.

A perpendicular FH having been drawn from F onto AG, it is assumed, in the small triangle FGH, that the angle at G is equal to the angle BFA found before; for inasmuch as the difference that intervenes is very slight, it does nothing to harm our intention. Since therefore HG is given, the refraction of declination by observation — namely the difference of the apparent and true refraction with respect to declination — therefore FG, the refraction of altitude, cannot be lacking on its side; from which, in the right-angled triangle, one side together with another angle is obtained. And because the triangle is small, the operation will be carried through more compendiously, as if it were rectilinear. Indeed the matter comes out the same, whether one proceeds in this way or by the preceding ones.

By these methods, then, comparing both the observations made by the azimuthal quadrant and likewise those made by the larger armilla that measures the declinations, we have constructed a Table of Refractions, drawing on the counsel of the observations of several years and weighing those same observations diligently in the balance. [Margin: 10]

It must further be noted that, on the very day of the solstice — on which the declination changes imperceptibly — these procedures cannot be carried out in practice, on account of the less convenient clear weather, such as is required (the purest possible) from the Sun's rising to its setting; and that one must apply the reckoning of the change that successively occurs in the declination.

It appears, moreover, from the Table itself that these refractions near the horizon are liable to sudden alteration; but afterwards, once the Sun has been raised

higher, they diminish step by step. The chief cause of this is that around the boundary [Finitor] the density of the vapors is drawn out very far, and the same density, in that same place, is at once cut short by a slight change of altitude, but not so when higher up. For, having assumed the greatest elevation of the vapors — demonstrated by the opticians Alhazen [Ibn al-Haytham] and Vitellio [Witelo] to be $\frac{1}{48}$ of the Earth's semidiameter being 60 parts — so that in German miles it is scarcely 12, their thickness around the horizon itself comes out to be $\frac{9}{55}$, or 142 miles. At an altitude of $\frac{15}{16}$ of the semidiameter, that is, $41\frac{1}{2}$ miles; close to an altitude of 30 degrees, $\frac{1}{36}$, or about 23 miles; around the middle of the quadrant, $\frac{1}{8\frac{3}{4}}$, and in miles $16\frac{1}{3}$; at an elevation of 60 parts, $\frac{1}{58\frac{3}{4}}$, or 14 miles — as can be demonstrated more conveniently elsewhere, lest we dwell on these matters too long here. [Margin: 18]

And hence it is sufficiently plain why the thickness of the vapors so suddenly alters itself in a position lower toward the horizon, but afterwards [alters] less; and why the same thing must happen also in the refractions, even from this single cause, which (as I said) is the more evident in those that arise. It is also clear from this for what reason the Sun seems to rise daily sooner, and to set later, than it actually does — so much so that it appears to stand entirely with its whole body above the horizon when in reality no part of it, risen or descended, would deservedly [be there]. And therefore the day, which we call the natural [day], is always longer according to the apparent rising and setting of the Sun than astronomical calculation admits at a given pole altitude; and how this comes about has hitherto been explored by very few — although for some, perhaps, this visible lingering of the Sun above the horizon, exceeding the astronomical numbers, may have been ascertained by a certain experiment. [Margin: 30]

That, moreover, these refractions become imperceptible around the 45th degree of altitude — though the thickness of the vapors there reaches nearly 14 miles — does not happen so much because of their attenuation, but much more because the light of the Sun and stars, penetrating more directly, is least impeded, so that it reaches us wholly unrefracted. For it is demonstrated in the *Optics* that the stars around the zenith — even if their light shines upon us through many transparent media — nevertheless appear without refraction. Hence in the places near to this [zenith], even if [the case is] not exactly the same, yet the reasoning is not very different, especially since the impediment from the differing transparent media is not so very great.

If, the refraction in the altitude circle being known, one should wish, with respect to the equator, to convert it into declination and right ascension, this will be done

without difficulty by the adjoining drawing, which by itself is sufficiently intelligible to the skilled. [Margin: 10]

Diagram. A semicircle on the horizontal base N–O–M–P. Within it, on the left side, are clustered the letters E, F (upper), H, G, Q (middle), L, I, K (lower left), with arcs drawn across to the base points O and M and toward the right. In the triangle EFG, the arc EF is the distance of the poles of the horizon and the equator, which is not unknown; GE is the complement of the true altitude, [found] by subtraction of the known refraction from the observed altitude; GF the complement of the true declination, [found] through the inquiry into the Sun's place. From these three known sides, the angle EGF [recte: EFG] becomes plain.

- E (upper, near apex): pole/upper vertex of construction
- F (upper right): pole point
- H (below E): intersection point
- G (center-left): vertex
- Q (right of G): intersection point
- L (left): point on arc
- I (below L): point on arc
- K (lower left): point on arc
- N (base, left): left end of base
- O (base, left-center): point on horizon
- M (base, center-right): point on horizon
- P (base, right): right end of base

Thereafter, in the triangle HGQ [recte: per constructionem the right-angled triangle], since the side HG is known — namely the refraction of altitude — and the angle HGQ, the same as EGF, has now become known, the two remaining [sides] will also be found: HQ of the right ascension, and GQ of the declination, representing the refractions, which must be accommodated to the diversity of position.

They can also be derived by a not very dissimilar method, provided the angle that the vertical circle makes — in its given position with respect to the ecliptic — be established, the refractions being distributed into longitude and latitude with respect to the ecliptic, which has been sufficiently shown elsewhere. And the Tables that distribute the solar parallaxes into longitude and latitude, calculated by some time ago, are not without use for this business — except that this caution must be observed: that the refractions make the Sun higher in the vertical circle than it really is, but the parallaxes lower. For this reason the differences of

longitude and latitude must be applied differently — which, for those who understand the matter itself, will not be difficult [to grasp] from the diversity of positions. Now, having dwelt long enough on the refractions (a thing I have admitted the more willingly because, so far as I know, these have not been diligently investigated by others before), let us direct our pen to the consideration of the parallaxes.

On the Parallaxes of the Sun, and Their Table

De Parallaxibus Solis & earum Tabula.

The parallaxes of the Sun in the circle of altitude arise from the fact that the semidiameter of the Earth [semidiameter Terrae] does not bear an utterly negligible proportion to the Sun's distance. The Sun's remoteness is determined chiefly through lunar eclipses, from the diameter of the Earth's shadow at the place where the Moon passes through it, and from there the mutual comparison of these three bodies—matters more conveniently to be treated elsewhere. Here, then, we shall assume the semidiameter of the eccentric of the Sun [semidiameter Eccentrici Solis] to be of the size that Copernicus investigated from eclipses: namely, 1142 of the Earth's semidiameters. If some slight discrepancy creeps in here, it in no way disturbs the matter we are pursuing. And since the distance of the Sun from the Earth can be given in those parts of which the semidiameter of its eccentric is 100000 (as will presently be evident), that same distance in terms of the Earth's semidiameters will likewise not be unknown for any given position.

In the figure assigned—which we also used in working out the prosthaphaereses [prosthaphaereses]—since in the triangle BCD two sides are known, namely BD, the semidiameter of the eccentric, and DC, the eccentricity, and the angle BDC is also established from the distance of the Sun's mean motion from its apogee [apogaeum], therefore not only the prosthaphaeresis through the angle DBC (about which we spoke earlier) but also the side BC can be made known, which measures the remoteness of the Sun from the Earth's center. This is in such parts as BD is assumed to be given—namely, 100000, or whatever quantity one likes. Then, by assigning to the quantity BD, the semidiameter of the eccentric, the Earth's semidiameters (as I said) 1142, the Earth's semidiameters [for BC] are very easily resolved by the rule of proportions.

Diagram. A circle with two perpendicular diameters drawn, forming the framework for the triangle BCD used in the prosthaphaeresis and distance computation. The vertical diameter runs from A (top) down through the interior

to E (bottom); the horizontal axis runs to B (left). From B two lines are drawn toward the interior region near D and C.

- A (top of circle): vertex A
- B (left, on circumference): vertex B (the position of the Sun toward which lines are drawn)
- D (interior, right of center): point D
- C (interior, just below D): center / point C
- E (bottom of circle): vertex E

So that the distance of the Sun from the Earth throughout its whole course might be evident at a glance, I have added a little table [Tabellam] which displays the Sun's elongation from the Earth's center—at every fifth degree of remoteness from the apogee—both in numbers of the kind in which the semidiameter of the eccentric is presupposed to be 100000, and in the Earth's semidiameters themselves. Wherever anything exceeded whole semidiameters, I resolved it into sexagesimal minutes [scrupula], as though one semidiameter contained 60 parts. Accordingly, one such minute will comprise $14 \frac{1}{3}$ ordinary miles [miliaria vulgaria], of the kind of which the Earth's semidiameter is assumed to have 860.

If anyone, more curious, should wish to convert into miles not only the adhering minutes but the very semidiameters of the Earth by which the Sun is removed, he will easily accomplish this by multiplying the assigned semidiameters of the Earth by 860, and

[The table on the following page is framed left and right by columns naming the months of the Julian year that correspond to each degree of remoteness from the apogee.]

Table of the Sun's Distance from the Earth

TABVLA DIST: ☉ A TERRA.

The outermost left and right vertical bands carry the month-names (Julian year) corresponding to each remoteness; they are transcribed as the first and last columns below. The header "In P. qualium Semid. Ecc. 100000" = "In parts of which the semidiameter of the eccentric is 100000"; "In Semidiamet. Terrae / M." = "In Earth's semidiameters / minutes"; "Dist. ab Apog." = "Distance from apogee" (degrees).

Menses (left)	Dist. ab Apog.	In P. (Semid. Ecc. = 100000)	In Semidiamet. Terrae	Dist. ab Apog.	Menses (right)
IVNIVS	0	103584	1182	360	IVLIVS
	5	103571	1182	355	
	10	103532	1182	350	
	15	103466	1181	345	
IVLIVS	20	103375	1180	340	MAIVS
	25	103259	1178	335	
	30	103119	1177	330	
	35	102956	1175	325	
	40	102771	1173	320	
	45	102566	1171	315	
	50	102341	1168	310	
AVGVST VS	55	102098	1165	305	APRILIS
	60	101839	1163	300	
	65	101567	1159	295	
	70	101232	1156	290	
	75	100987	1153	285	
	80	100684	1149	280	
SEPTEM BER	85	100376	1146	275	MARTIVS
	90	100069	1142	270	
	95	99752	1139	265	
	100	99440	1135	260	
	105	99133	1132	255	
	110	98832	1128	250	
OCTOB ER	115	98539	1125	245	FERRVARI VS [sic]
	120	98257	1122	240	
	125	97988	1119	235	
	130	97735	1116	230	

Menses (left)	Dist. ab Apog.	In P. (Semid. Ecc. = 100000)	In Semidiamet. Terrae	Dist. ab Apog.	Menses (right)
	135	97498	1113	225	
NOVEM BER	140	97282	1110	220	IANVARIV S
	145	97086	1108	215	
	150	96913	1106	210	
	155	96764	1105	205	
	160	96640	1103	200	
	165	96543	1102	195	
DECEM BER	170	96472	1101	190	DECEMBE R
	175	96430	1101	185	
	180	96416	1101	180	

[Resuming the main text, in the right-hand column alongside the table:]

The minute that is appended is also distributed among the 14 $\frac{1}{3}$ miles; and from this, both sums collected together will fulfill the wish—namely, by how much the Sun, measured in miles, is removed from the Earth's center. But if anyone is eager to know its distance from the Earth's surface, he will easily obtain that by subtracting a single semidiameter, that is, 860 miles. Yet this resolution into miles is too fussy and superfluous; for it is enough to know it in the Sun's Earth-semidiameters. Indeed, to obtain exact precision even in these, in this place, is very difficult.

I have also added on either side the months of the Julian year that correspond to such a remoteness in these present centuries—and this by way of a broader indication, since a precise distinction in this matter is less fitting and is found to be idle in itself.

This too is worth considering: that the Sun, near its apogee, is more remote from the Earth than it is near its perigee [perigaeum] by about 82 semidiameters—that is, by a little more than seventy thousand miles. In this age, moreover, the center of the eccentric of the Sun is distant from the Earth by about 41 semidiameters and roughly thirty-five thousand miles; from which it is removed by no small interval, but very nearly reaches as far as the nearest revolutions of the Moon

(falling short, at least, of the fifth part of the whole distance to the Moon's bounds—this is evident.

But we have arranged the Sun's parallaxes for a threefold elongation from the Earth—namely, the greatest, around the apogee; the nearest, near the perigee; and intermediate positions on either side—and this by the adjoined method of demonstration.

In the figure set alongside, AC is the semidiameter of the Earth, while CF is the interval to the Sun, at whatever distance was taken from the previous reasoning. Let the Sun, then, be, for example's sake, first near B, on the horizon itself, since in the triangle ABC the distance BC of the Sun from the Earth's center is given in a definite measure, or in its semidiameters, of which AC is one part (which, for the convenience of operation, can—with five ciphers added—be assumed as 100000, and BC likewise expanded by as many).

Diagram. A large circle (the Sun's orbit) with two perpendicular diameters meeting at C, the Earth's center. A small circle around C represents the Earth (with semidiameter AC, A being a point on it just above C). From C the vertical diameter runs up to F (top) and down to G (bottom); the horizontal diameter runs to F[?] (left) and B (right). The Sun is shown at B on the horizon and at D higher up in a vertical circle; lines are drawn from A and C to D, illustrating the parallax angles.

- F (top of large circle): vertex F (the zenith/vertical direction)
- D (upper right, on circumference): position of the Sun at a given altitude
- A (small interior point above C): point on the Earth's surface; AC = Earth's semidiameter
- C (center): the Earth's center
- B (right, on circumference): position of the Sun on the horizon
- F (left, on circumference): point F [the left label reads "F"; same letter as the top — transcribed as printed]
- G (bottom of large circle): vertex G

And since the angle at C is a right angle, the angle at B—which measures the maximum parallax on the horizon—cannot be unknown. In just the same way, when the Sun is raised in the vertical circle to D, at some definite altitude, since in the triangle ADC the side CD, the remoteness of the Sun from the Earth, is established (and AC the Earth's semidiameter, as before), while the angle CAD is the complement, to two right angles, of the presupposed altitude of the Sun—for it is the distance from the zenith, which is derived from it—therefore the angle

ADC will be evident, exhibiting the parallax of the Sun appropriate to such an elevation. And by this method we have computed its parallaxes for every single degree of altitude, from the horizon to the zenith, and that for the threefold distance from the Earth (as I said above): the greatest, the mean, and the least.

For although the difference is exceedingly small—seeing that even on the horizon itself, between the most remote and the nearest interval, it scarcely exceeds the fifth part of one minute—nevertheless, so that satisfaction might be given in every way to a more accurate observation, such as can be made by larger and more perfect instruments (of which we have not a few at hand), I did not think it superfluous to apply this scrupulous care. Now the Sun is at its greatest remoteness around the summer solstice [solstitium aestivum], or rather a little after, in the month of June; at its greatest [nearness] near the winter [solstice] in December; and near its mean elongation at both equinoxes, in March and September. And from this the remaining differences, which are of no great moment, come out as ones not to be wondered at.

Just as refractions near the horizon are suddenly much altered, while in a higher position they change gradually, so the parallaxes, by contrast, remain nearly alike for a long while near the horizon, but tending toward the zenith they acquire a swifter change. It must also be carefully noted that the parallaxes render the Sun lower than its true place in the vertical circle, whereas the refractions, conversely, raise it too high—matters to be considered in their use, as we have also pointed out before. That the apparent place of a star is perpetually subject both to refraction and to parallax, while the true place is free from both, in the same vertical circle, I judge to be better known to the skilled than to need much investigation; indeed, it is sufficiently gathered of itself from what has been said before.

On the Declinations of the Parts of the Ecliptic, and the Table Pertaining to This

De Declinationibus Partium Eclipticae, & quae huc pertinet Tabula.

The obliquities of the degrees of the ecliptic, by which they are separated from the equator, may be investigated in the following manner by the reasoning of the adjoined figure.

Diagram. A quadrant figure: a curved arc (the ecliptic quadrant) HKM running from H at the left down to M at lower right, with the chord/base HM. A vertical line IK descends from I (on the upper arc, at top) to K (on the lower arc), with L marked to the right. H is the point of intersection of ecliptic and equator.

- H (left): the point where the ecliptic and equator intersect
- I (top, on the upper arc): point I
- L (right, beside the line foot): point L
- K (middle, on the lower arc): point K, where arc IK meets the lower arc
- M (lower right): point M, the point of maximum declination

Let HKM be the quadrant of the ecliptic, HIL [that] of the equator, which intersect each other at the point H. The maximum declination, by which they are removed from each other, is LM, which—by a special method, from several accurate observations of preceding years, namely from the altitude of the pole, and therefore the equator, precisely known, and from the Sun at the summer solstice, where it is not subject to any sensible refraction, [taken] at its greatest elevation with its parallax added—I have found to be $23^{\circ} 31' 1/2'$, as is also indicated several times elsewhere. Suppose we wish to know the declination of the point K on the ecliptic, which the arc IK measures, drawn orthogonally to the equator. Since, then, in the right triangle HIK, right-angled at I, the angle IHK is given, which the maximum declination measures, and the side HK by the assumed interval of the proposed point of the ecliptic from its contact with the equinoctial, it is readily at hand; therefore, given the other angle of the right triangle, together with the side opposite the right angle, the side IK will not escape us, showing the declination sought.

And in this way, throughout the whole quadrant, we have set down a table of declinations not only for the single degrees but also for their sextants [sextantes]. I have, moreover, applied a still finer distribution down to every tenth minute, because the differences of the declinations do not stand in proportion to the single degrees alone, if one's use requires the smallest particles of the minutes to be drawn out. What has been rightly established in one quadrant is conveniently applied to the remaining three; in this

provided that the signs and degrees that share the same declination are properly arranged with respect to one another, just as was done in the Canon itself.

Moreover, this same table can easily be resolved down to each individual minute of the ecliptic, by means of the difference interpolated between any ten-minute intervals (that is, by continually adding a tenth part), so that the investigation of the declination from a given solar position becomes more convenient, or the reverse. I also have ready at hand such a table, serviceable for everyday use, which it would have been too tedious to set out here.

Furthermore, craftsmen have found, over the long passage of time, that the greatest declination changes, and that the remaining intermediate ones change along with it. Indeed, in the age preceding Ptolemy [Ptolemaeus] and that of several earlier astronomers it was $23^{\circ} 51\frac{3}{4}'$ [Margin: p. 23. /. $51\frac{1}{2}'$.], nor is any greater value found recorded in any monument of the ancients. For this reason our table here cannot be universal, but at least serves this present age conveniently; whereas the tables computed by others presuppose a greatest declination of $23^{\circ} 28'$ [Margin: p. 23. /. $28'$.], falling short of the true value by $3\frac{1}{2}$ minutes. As for this change in the declination — how it can be accommodated to one age after another — I shall set out my view elsewhere (God willing). Copernicus's [Copernicus's] subtle speculation can scarcely hold up here, much less what others have presented in a tangled fashion.

[Margin: 13]

On the Right Ascensions of the Degrees of the Ecliptic, and the Construction of Their Table

[De Ascensionibus Rectis, Graduum Eclipticae, & Tabulae earum constructione.]

[Margin: 13]

From the given declinations of the individual degrees, their right ascensions too are subjected to calculation without difficulty. For in the adjoining figure — where A represents the northern pole of the zodiac, O the southern; P the arctic pole of the equator, D the antarctic, the two of them; while the circle ABDE is the colure of the solstices, EHB the ecliptic, and FHC the equator — lines are drawn from each of the poles to the proposed points of the ecliptic, all the way to the equator, as is plain.

Diagram. A sphere shown in projection, carrying the principal great circles used to derive the right ascension of a point of the ecliptic from its declination. The northern pole of the zodiac (A) stands near the top, the southern (O) at the bottom; the arctic pole of the equator (P) is at the top and the antarctic (D) at the bottom. The solstitial colure is the circle through A, B, D, E; the ecliptic is the oblique circle EHB; the equator is the circle FHC. From the points K and L of the ecliptic (whose right ascensions are sought) arcs are drawn through the poles down to the equator.

- A (top): northern pole of the zodiac [Polus Zodiaci Boreus]
- P (top, near A): arctic pole of the equator [Polus aequatoris arcticus]

- B (upper right): point of the solstitial colure / ecliptic
- C (right): point on the equator
- E (left): point of the colure
- F (left): point on the equator
- N, G, H (middle, left of center): intermediate points on the projected circles
- K (center): point of the ecliptic whose right ascension is sought
- L (center-left, below K): second point of the ecliptic
- I, M (center, right of K): points marking declination/ascension arcs
- D (bottom): antarctic pole of the equator
- O (bottom, right of D): southern pole of the zodiac [Polus australis]

[Here in the figuration — where K and L are understood to be the positions of the ecliptic whose right ascension we intend to determine — since by the foregoing procedure, or by the table...]

of the same [table] there are given the declinations KI and GL, together with the greatest obliquity, which the angle BHC (or FHE) defines, the right ascension is derived as follows. In the right triangle HKI, right-angled at I — since the side HK is established (the distance from the mutual intersection of the circles) and KI is the declination of that same point — it will be possible to know HI, the right ascension to be reckoned along the equator from that same place of intersection, which was what was sought. And in the same way we shall also obtain what is sought on the other side, toward the southern pole.

By this method I have constructed a Table of Right Ascensions sufficient for the individual parts of the ecliptic; a finer subdivision is not particularly necessary in this place, since the differences of neighboring degrees do not vary so very much. If, however, anyone should prefer to be more scrupulous here, he will be able — by the method described — to extend this little table too to each ten-minute interval, as we did for the declinations.

The numbers of this Canon are indeed altered along with the variation of the ecliptic's inclination to the equator — though not by very much, but by a certain very slight difference; yet if everything is to be examined precisely, it is not to be neglected. For this reason we judged it worthwhile to rectify this Table too, exactly, to the truer greatest obliquity of our age — since the tables intended for this purpose by others rest on a less-than-reliable declination of the ecliptic as their foundation. And I thought this all the more worth doing because this little table affords no small use in astronomical matters: if at any time, in this whole work, the right ascension of parts of the ecliptic should be required, it could be

drawn from here most easily, so that it would be ready at hand. And let this much suffice as our account of the construction of the preceding tables. Now we shall briefly take in some use of them, by one example or another.

[Margin: 14]

The Use of the Preceding Tables, by Examples

[Usus antecedentium Tabularum per exempla.]

[Margin: 15]

In this very year in which we write this, 1588, on the next-to-last day of January, we carefully observed the meridian altitude of the Sun — comparing several instruments — at $19^{\circ} 17\frac{1}{2}'$ [Margin: p. 19. /. $17\frac{1}{2}'$]. To this, from the Table of Solar Refractions, corresponds a refraction of $4' 50''$ [Margin: /. 4. //. 50.], which, when subtracted from the apparent elevation (because refraction always raises the heavenly bodies higher than is right), yields the altitude free of refraction at $19^{\circ} 12' 20''$ [Margin: p. 19. /. 12. //. 20.], such as is seen from the surface of the Earth. This is therefore still subject to parallax. So in the Table of Parallaxes, by taking — for the 19th degree of altitude — that variation of aspect which falls between the smallest and the mean distance from the Earth, that parallax is found to be $2' 54''$ [Margin: /. 2. //. 54.]. This, added to the prior altitude already corrected for refraction (because parallax makes the Sun appear lower than it ought), gives the Sun's true elevation, freed from both refraction and parallax, at $19^{\circ} 15\frac{1}{4}'$ [Margin: p. 19. /. $15\frac{1}{4}'$]. If this is subtracted from the elevation of the equator of this place where the observation was made — which is $34^{\circ} 51\frac{1}{4}'$ [Margin: g. 34. /. $51\frac{1}{4}'$] — there results...

there results the exact declination of the Sun, $14^{\circ} 50'$ [Margin: p. 14. /. 50.]. When this is brought into the field of the Table of Declinations laterally — the due correction for proportional reckoning having first been made (as is well known) — it shows the longitude of the Sun in $20^{\circ} 6\frac{1}{4}'$ of Aquarius [♈] [Margin: /. $6\frac{1}{4}'$. ♈]. To this there afterward corresponds, from the Table of Right Ascensions, an ascension — corrected as is the custom — of $308^{\circ} 29' 58''$ [Margin: p. 308. /. 29. //. 58.]. But as for the longitude, our calculation, derived from the modern restoration and the tables of the Sun's motions presented above, gives its position for the meridian of 30 January at $20^{\circ} 6' 23''$ of Aquarius [♈] [Margin: p. 20. /. 6. //. 23. ♈], so that it differs from the observation itself by at least an eighth part of one minute — a tiny difference that is altogether imperceptible.

The Prutenic computation [Abacus Prutenicus], derived from Copernican sources, gives the longitude of the Sun in $19^{\circ} 33'$ of Aquarius [♈] [Margin: p. 19. /. 33. ♀], which falls short of the truth by a little more than 33 minutes — that is, by upwards of half a degree. The Alphonsine [Alphonsina] reckoning then numbers the place of the Sun at $20^{\circ} 24'$ of Aquarius [♈] [Margin: p. 20. /. 24. ♀], and so exceeds the truth by nearly 18 minutes.

[Margin: 14]

Now we shall give a second example, with the Sun positioned near the middle of Scorpio [♏]. On 26 October of this same year 1588, the altitude of the Sun was observed here on the meridian at $18^{\circ} 17'$ [Margin: p. 18. /. 17.], precisely enough. From this, refraction subtracts $5' 33''$ [Margin: /. 5. //. 33.], and parallax adds $2' 55''$ [Margin: /. 2. //. 55.], so that the true altitude, with refraction and parallax removed, is $18^{\circ} 14' 25''$ [Margin: p. 18. /. 14. //. 25.]. When this is subtracted from the previously assigned elevation of the equator, it leaves the Sun's true declination, $15^{\circ} 50' 50''$ [Margin: p. 15. /. 50. //. 50.]; to this there corresponds, from the Table of Declinations, the longitude of the Sun in $13^{\circ} 10'$ of Scorpio [♏] [Margin: p. 13. /. 10. ♀], which agrees well enough with our own rectification of its course. For it shows its position there at $13^{\circ} 9' 50''$ of Scorpio [♏] [Margin: g. 13. /. 9. //. 50. ♀], so that only a sixth part of one minute — which is not perceptible to the senses — is wanting. The right ascension, for the observed place of the Sun, is found by squaring [i.e. computed] from its own table as $220^{\circ} 41' 47''$ [Margin: part. 220. minut. 41. sec. 47.].

But each calculation, the Copernican as much as the Alphonsine, here too deviates too far. For Copernicus's reckoning, giving the longitude in $12^{\circ} 56'$ of Scorpio [♏] [Margin: p. 12. 56. ♀], falls short by nearly three-quarters of a degree; while the Alphonsine supputation places it at $13^{\circ} 17'$ of Scorpio [♏] [Margin: g. 13. /. 17. ♀], exceeding it by almost an eighth part of a degree.

From these two examples that we have adduced, it becomes manifest, in the observation of the Sun near the middle of Aquarius [♈] and of Scorpio [♏], that its motion, predefined by us through the modern correction, agrees precisely enough at these places of the zodiac too — provided, of course, that due caution is applied regarding refraction and parallax. We shall accordingly establish above the investigation of the Apogee [Apogaeum] and Eccentricity [Eccentricitas] not at the middle of these signs, but rather at Taurus [♉] and Leo [♌], which are more elevated (so that refraction would interpose no obstacle), by comparison made with the equinoctial ingresses.

It is also clear from this that when, earlier, I discussed the occasions on which Copernicus slipped concerning the Sun's Apogee and Eccentricity, and in setting in order the whole of its course, I did not detract from that man's inventions more than was just, since I showed only that the Sun, at the middle of Scorpio [♏], had been less exalted by at least 4 minutes, on account of refraction, than he himself supposed...

which might be able to alter that figure of 13 in its longitude by a closely comparable minute, I would assert it. For if we look back to the Table of Refractions, the refraction near that altitude can turn out still greater — namely close to 4' 50" [Margin: /. 4. //. 50.] — which alters the Sun's longitude, in the middle parts of that sign, by at least 16 scruples [minutes]; and the Sun traverses these in scarcely 6½ hours. But I preferred to introduce that error of 4 minutes there, on account of refraction, in the position, rather than to appear too excessive against the opinions and observations of so great a man. For it can indeed happen that refraction, near that place of altitude, does not exceed four scruples [minutes]; but then there must be present not merely the very best clear weather, but also air uniformly very pure and clarified, so that it is as little as possible subject to the Earth's vapors. That this very rarely happens in that horizon where Copernicus set up his observations, one may gather even from this: that he himself complains, in Book V, Chapter 30, where he treats of the more recent observations of Mercury, that the Vistula breathes there an air too impure, and seldom affords a calm and settled condition — so much so that he never (astonishing as it is) succeeded in any observations of Mercury at all. Instead he relies on those which he was compelled to borrow from Bernhard Walther [Bernardus Waltherus], the pupil of Regiomontanus [Regiomontanus], and from Johann Schöner [Iohannes Schonerus] — though not even these (let me note this too in passing here) were, for certain reasons, sufficiently exact.

Nor is there any reason for Copernicus to complain, on top of this, of the great obliquity of the sphere at his location, since we — still more remote toward the north, and inhabiting a yet more oblique position of the sphere — have many times seen the planet Mercury, both in the morning and in the evening, and have carefully measured it from the heavens by means of instruments, sometimes on several days running. Indeed, scarcely a year has passed since we applied a more assiduous attention to these contemplations, but that Mercury has been noted by us and accurately determined by the proper instruments. But I return to the matter.

Refraction, therefore, can in no way prejudice the excessive [number] of Copernicus's observation, since by scarcely one minute it can be greater than the reckonings of our own Canon, and on that account introduce more variability into the Sun's place. In that table I deliberately noted those refractions which for the most part occur under a sufficiently clear sky, and which behave in roughly a middling manner — although at times such purity and subtlety of the air, and clarification from vapors, can exist that at 19 degrees of altitude scarcely 4 minutes of refraction make themselves felt, even though the little table presents five; and likewise for the rest. For to limit these things to the very nail — so that nothing at all is wanting or in excess — is, on account of the fact that even the most serene air does not always have exactly the same purity, simply impossible. But of these matters enough and more than enough.

I have now explained the structure of the preceding tables, and some such use of them: the rest, those for whom we write — being intelligent and practiced — will readily supply of themselves, and will apply more fully to their intended purpose. We, hastening on to other matters, do not think we should dwell on these any longer.

All these preceding matters — set out from the beginning of this chapter, on directing the Sun's course exactly according to the standard of the celestial path — would certainly suffice for a competent verification in our own recent centuries. But since a great deal of advantage flows from the entries and revolutions to be derived from them — not only in astronomical work, but also in what bears on astrology, which investigates the influences of the heavenly bodies — it seems worthwhile to dwell a little longer on drawing these out, since their usefulness is very great and the proper method of treating them is the more correct one. For others — not only those who have relied on the Alphonsine foundations, but even those who rely on the foundations of that distinguished man Copernicus — have in this respect strayed from the heavens themselves, indeed (as the saying goes) from very nearly the whole heaven. Indulging too credulously in the subtle allurements of numbers, they have neglected to derive the truth from above, the truth that lies hidden in what is concealed. [Margin: 10]

Now since these same entries and returns, when reckoned to the same point of the ecliptic from any point whatever, do not everywhere present themselves in the same way — but rather different and varying restitutions of other points of the ecliptic are detected in the Sun's path — I shall first arrange, in a table of its own, the Sun's entries into the individual twelve-parts [dodecatemoria] of the zodiac for the beginnings of three nearby centuries, namely for the years 1500,

1600, and 1700. From these I shall gather the annual quantity for the beginnings of all the signs, and I shall set it out in a second adjoining little table. By the help of these two tables I shall afterwards present, in two distinct tables that nonetheless recur to the same result, the more particular measurements of the revolutions for the individual intervening years and the years that fall between. These will be preceded by a certain small table of the Sun's entry into the cardinal points of the zodiac, both the Alphonsine and the Coper- [Margin: 16]

—nian, set before those very centuries, so that it may be established how much discrepancy there is between the heaven itself, from which our own computations are derived, and the numbers of the tables that have been in use up to now.

In these initial years, separated by a full century, I have applied not only a reckoning of how much the solar apogee can shift in the meantime, but also taken account — without omitting it — of a small alteration in its eccentricity that occurs in the interval. For that seemed necessary. Although the variation of the eccentricity may be slight in one century or another, this variation, however small, nonetheless perceptibly alters the times of the entries. [Margin: 11]

As for the method of the eccentricity's change — derived from the observations of the ancients faithfully collated with our own, as far as I have so far found it out — a more suitable occasion for setting it out will be given elsewhere (with the favor of the Supreme Will), where I shall treat *ex professo* of the universal restoration of the Sun's course.

It should be further noted that, even though the annual quantities composed with respect to the individual signs do not remain exactly equal in one century or another — on account of the continual change of the apogee and the eccentricity (to say nothing now of the inequality of the precession of the equinoxes) — nonetheless I have so adapted this enumeration to pairs of centuries that, if some tiny difference should now and then slip in, it will be of no consequence. And therefore I have compared the entry of the year 1500 with the year 1700 rather than with each other in turn, so that the greater span between the two centuries might make us more certain of the time particularly intercepted. Now I shall append the tables I have promised, intending afterwards to explain their use briefly.

Table of the Sun's entries into the individual twelve-parts [dodecatemoria] of the ecliptic, adapted from our own computations for the beginnings of the three nearest centuries.

The left block gives, for each zodiac sign the Sun enters and its corresponding month, the day (D.), hour (H.), and minute (M.) of entry for 1500, 1600, and 1700. The right block ("Little table of the annual quantity, within the twelve signs of the zodiac, which contains, beyond the complete 365 days...") gives the hours (H.), minutes ('), and seconds (") of the excess over 365 days, keyed to the beginning of each sign (Initia Signorum).

Entry (☉ in)	M o n t h	15 00 D.	15 00 H.	15 00 M.	16 00 D.	16 00 H.	16 00 M.	17 00 D.	17 00 H.	17 00 M.	Annu al qty. H.	Annu al qty. '	Annu al qty. "	Sig n beg un
♈	M ar t.	10	13	35	9	18	30	8	23	20	5	48	31 ½	♈
♉	A pr il.	10	4	48	9	9	11	8	13	31	5	48	13	♉
♊	M ai us	11	7	59	10	12	5	9	16	8	5	48	4	♊
♋	Ju ni us	11	18	39	10	22	47	10	2	53	5	48	3	♋
♌	Ju li us	13	6	24	12	10	48	11	15	15	5	48	15 ½	♌
♍	A u g us t.	13	12	16	12	17	18	11	22	19	5	48	37	♍
♎	Se pt.	13	7	18	12	12	55	11	18	33	5	48	58 ½	♎
♏	O	13	13	4	12	19	12	12	1	20	5	49	17	♏

Entry (☉ in)	M o n t h	15 00 D.	15 00 H.	15 00 M	16 00 D.	16 00 H.	16 00 M	17 00 D.	17 00 H.	17 00 M	Annu al qty. H.	Annu al qty. '	Annu al qty. "	Sig n beg un
	ct o b.													
♈	N o u.	12 D.	6 H.	52 M	11 D.	13 H.	16 M	10 D.	19 H.	42 M	5 H.	49	27	♈
♊	D e c e b.	11 D.	17 H.	9 M	10 D.	23 H.	32 M	10 D.	5 H.	59 M	5 H.	49	27	♊
♈	Ia n u ar .	10 D.	2 H.	27 M	9 D.	8 H.	30 M	8 D.	14 H.	33 M	5 H.	49	14	♈
♈	Fe br .	8 D.	17 H.	26 M	7 D.	22 H.	58 M	7 D.	4 H.	26 M	5 H.	48	54	♈

Table showing the Sun's entry into the four cardinal points, at the beginnings of these three centuries, according to the Alphonsine and Copernican computation, together with the difference from our own.

The left columns give the Alphonsine computation (Calcul. Alph.): day (D.), hour (H.), minute (M.), then the difference from our own value (Diff. à nostro) in hours and minutes, with the sense (min. = less / plus = more). The right columns give the Copernican computation (Calcul. Coper.) in the same form.

Y e a r	Mo n t h	☉ in	Alp h. D.	Alp h. H.	Alp h. M.	Diff . H.	Diff . M.	s e n s e	Cop er. D.	Cop er. H.	Cop er. M.	Diff . H.	Diff . M.	s e n s e
15	Ma rtij	♈	10	7	0	6	35	m i	10	16	28	2	53	p l

Y e a r	Mo nt h	$\odot$ in	Alp h. D.	Alp h. H.	Alp h. M.	Diff . H.	Diff . M.	s e n s e	Cop er. D.	Cop er. H.	Cop er. M.	Diff . H.	Diff . M.	s e n s e
0 0								n .						u s
1 5 0 0	Iu ni us	$\mathfrak{E}$	11	13	5	0	34	m i n .	11	16	0	2	39	m i n .
1 5 0 0	Se pte b.	$\underline{\mathfrak{E}}$	13	7	22	0	4	p l u s	13	1	20	5	58	m i n .
1 5 0 0	De ce b.	$\mathfrak{V}$	11	11	13	5	56	m i n .	11	16	50	0	19	m i n .
1 6 0 0	Ma rtij	$\mathfrak{V}$	9	13	5	5	25	m i n .	10	9	0	14	30	p l u s
1 6 0 0	Iu ni us	$\mathfrak{E}$	10	23	23	0	38	p l u s	11	5	26	6	39	p l u s
1 6 0 0	Se pte b.	$\underline{\mathfrak{E}}$	12	13	27	0	32	p l u s	12	16	40	3	45	p l u s
1 6 0 0	De ce b.	$\mathfrak{V}$	10	18	7	5	25	m i n .	11	11	12	11	40	p l u s
1 7	Ma rtij	$\mathfrak{V}$	8	19	12	4	8	m i	10	2	10	26	50	p l

Y e a r	Mo nt h	☉ in	Alp h. D.	Alp h. H.	Alp h. M.	Diff . H.	Diff . M.	s e n s e	Cop er. D.	Cop er. H.	Cop er. M.	Diff . H.	Diff . M.	s e n s e
0 0								n .						u s
1 7 0 0	Iu ni us	♋	10	4	45	1	52	p l u s	10	19	40	16	47	p l u s
1 7 0 0	Se pte b.	♊	11	19	31	0	58	p l u s	12	9	0	14	27	p l u s
1 7 0 0	De ce b.	♏	10	1	0	4	59	m i n .	11	6	20	24	21	p l u s

TABULA PRIMA [First Table].

Years (ANNI, repeated in both outer margins) against six zodiac signs (♈ Aries, ♉ Taurus, ♊ Gemini, ♋ Cancer, ♌ Leo, ♍ Virgo), each giving hours (H.) and minutes (M.) of the accumulated annual quantity.

A N NI	♈ H.	♈ M.	♉ H.	♉ M.	♊ H.	♊ M.	♋ H.	♋ M.	♌ H.	♌ M.	♍ H.	♍ M.
1	5	48	5	48	5	48	5	48	5	48	5	49
2	11	37	11	36	11	36	11	36	11	37	11	37
3	17	26	17	25	17	24	17	24	17	25	17	26
4	23	14	23	13	23	12	23	12	23	13	23	14
5	5	3	5	1	5	0	5	0	5	1	5	3
6	10	51	10	49	10	48	10	48	10	50	10	52
7	16	40	16	37	16	36	16	36	16	38	16	40
8	22	28	22	26	22	24	22	24	22	26	22	29

A	Г	Г	У	У	И	И	Э	Э	О	О	Н	Н
NI	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
9	4	17	4	14	4	12	4	13	4	15	4	17
10	10	5	10	2	10	0	10	1	10	3	10	6
11	15	54	15	50	15	48	15	49	15	51	15	55
12	21	42	21	38	21	37	21	37	21	39	21	43
13	3	31	3	27	3	25	3	25	3	27	3	32
14	9	19	9	15	9	13	9	13	9	16	9	20
15	15	8	15	3	15	1	15	1	15	4	15	9
16	20	56	20	51	20	49	20	49	20	52	20	58
17	2	45	2	40	2	37	2	37	2	40	2	46
18	8	33	8	28	8	25	8	25	8	29	8	35
19	14	22	14	16	14	13	14	13	14	17	14	24
20	20	10	20	4	20	1	20	1	20	5	20	12
25	1	13	1	5	1	1	1	2	1	6	1	15
30	6	16	6	6	6	1	6	2	6	7	6	18
35	11	18	11	7	11	2	11	2	11	9	11	22
40	16	21	16	9	16	2	16	3	16	10	16	25
45	21	23	21	10	21	2	21	3	21	11	21	28
50	2	26	2	11	2	2	2	3	2	13	2	31
60	12	31	12	13	12	3	12	4	12	15	12	37
70	21	36	22	15	22	3	22	5	22	18	22	43
80	8	41	8	17	8	4	8	5	8	20	8	49
90	18	47	18	19	18	4	18	6	18	23	18	55
100	4	52	4	22	4	5	4	7	4	26	5	2

Tables of the Revolutions of the Sun (continued)

REVOLUTIONS OF THE SUN — Libra through Pisces (Tabula Prima, continued)

This is the second half of the "Tabula Prima" (the first table of revolutions of the Sun), giving the accumulated hours (H.) and minutes (M.) for the remaining six zodiac signs — Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces — indexed by the number of completed years (Anni, in the outer columns at both left and right).

A													A
n	♎	♎	♏	♏	♐	♐	♑	♑	♒	♒	♓	♓	n
ni	H.	M.	H.	M.	H.	M.	H.	M.	M.	H.	H.	M.	ni
1	5	49	5	49	5	49	5	49	5	49	5	49	1
2	11	38	11	38	11	39	11	39	11	38	11	38	2
3	17	27	17	28	17	28	17	28	17	28	17	27	3
4	23	16	23	17	23	18	23	17	23	17	23	15	4
5	5	5	5	6	5	7	5	7	5	6	5	4	5
6	10	54	10	56	10	57	10	57	10	55	10	53	6
7	16	43	16	45	16	46	16	46	16	44	16	42	7
8	22	32	22	34	22	36	22	36	22	34	22	31	8
9	4	21	4	23	4	25	4	25	4	23	4	20	9
10	10	10	10	13	10	14	10	14	10	12	10	9	10
11	15	59	16	2	16	4	16	4	16	1	15	58	11
12	21	48	21	51	21	53	21	53	21	51	21	48	12
13	3	37	3	41	3	43	3	43	3	40	3	36	13
14	9	25	9	30	9	32	9	32	9	29	9	25	14
15	15	14	15	19	15	22	15	22	15	18	15	13	15
16	21	3	21	8	21	11	21	11	21	8	21	2	16

A n ni	$\underline{\mathfrak{L}}$ H.	$\underline{\mathfrak{L}}$ M.	$\mathfrak{M}$ H.	$\mathfrak{M}$ M.	$\mathfrak{X}$ H.	$\mathfrak{X}$ M.	$\mathfrak{Y}$ H.	$\mathfrak{Y}$ M.	$\mathfrak{Z}$ M.	$\mathfrak{Z}$ H.	$\mathfrak{H}$ H.	$\mathfrak{H}$ M.	A n ni
6													6
1 7	2	52	2	58	3	1	3	1	2	57	2	51	1 7
1 8	8	41	8	47	8	50	8	50	8	46	8	40	1 8
1 9	14	30	14	36	14	40	14	40	14	35	14	29	1 9
2 0	20	19	20	26	20	29	20	29	20	24	20	18	2 0
2 5	1	24	1	32	1	36	1	36	1	31	1	22	2 5
3 0	6	29	6	38	6	43	6	43	6	37	6	27	3 0
3 5	11	34	11	45	11	51	11	51	11	43	11	31	3 5
4 0	16	39	16	51	16	58	16	58	16	49	16	36	4 0
4 5	21	43	21	58	22	5	22	5	21	55	21	40	4 5
5 0	2	48	3	4	3	12	3	12	3	1	2	45	5 0
6 0	12	58	13	17	13	27	13	27	13	14	12	54	6 0
7 0	23	8	23	30	23	41	23	41	23	26	23	3	7 0
8 0	9	17	9	43	9	56	9	56	9	38	9	12	8 0
9 0	19	27	19	55	20	10	20	10	19	51	19	21	9 0
1 0 0	5	36	6	8	6	25	6	25	6	4	5	30	1 0 0

TABULA SECUNDA — Aries through Virgo (every fourth year)

The "Second Table" gives accumulated hours (H.) and minutes (M.) for the first six signs — Aries ♈, Taurus ♉, Gemini ♊, Cancer ♋, Leo ♌, Virgo ♍ — indexed by completed years in multiples of four (Anni 4, 8, 12, ... 100).

A n ni	♈ H.	♈ M.	♉ H.	♉ M.	♊ H.	♊ M.	♋ H.	♋ M.	♌ H.	♌ M.	♍ H.	♍ M.	A n ni
4	0	46	0	47	0	48	0	48	0	47	0	46	4
8	1	32	1	34	1	35	1	35	1	34	1	31	8
12	2	18	2	21	2	23	2	23	2	21	2	17	12
16	3	4	3	9	3	11	3	11	3	8	3	2	16
20	3	50	3	56	3	59	3	59	3	55	3	48	20
24	4	35	4	43	4	46	4	47	4	42	4	33	24
28	5	21	5	30	5	34	5	35	5	29	5	19	28
32	6	7	6	17	6	22	6	22	6	16	6	4	32
36	6	53	7	4	7	9	7	10	7	3	6	50	36
40	7	39	7	51	7	57	7	58	7	50	7	35	40
44	8	25	8	38	8	45	8	46	8	37	8	21	44
48	9	11	9	26	9	33	9	34	9	24	9	7	48
52	9	57	10	13	10	20	10	21	10	11	9	52	52
56	10	43	11	0	11	8	11	9	10	58	10	38	56
60	11	29	11	47	11	56	11	57	11	45	11	23	60

A n ni	Υ H.	Υ M.	ϣ H.	ϣ M.	Π H.	Π M.	Ϝ H.	Ϝ M.	Ϡ H.	Ϡ M.	Ⓜ H.	Ⓜ M.	A n ni
0													0
6 4	12	14	12	34	12	43	12	45	12	31	12	9	6 4
6 8	13	0	13	21	13	31	13	33	13	18	12	54	6 8
7 2	13	46	14	8	14	19	14	20	14	5	13	40	7 2
7 6	14	32	14	56	15	7	15	8	14	52	14	25	7 6
8 0	15	18	15	43	15	54	15	56	15	39	15	11	8 0
8 4	16	4	16	30	16	42	16	44	16	26	15	57	8 4
8 8	16	50	17	17	17	30	17	32	17	13	16	42	8 8
9 2	17	36	18	4	18	17	18	19	18	0	17	28	9 2
9 6	18	22	18	51	19	5	19	7	18	47	18	13	9 6
1 0 0	19	8	19	38	19	53	19	55	19	34	18	59	1 0 0

MINOR TABLE FOR THE INDIVIDUAL [YEARS] (Minor Tabella pro singulis)

The lower panel of this page gives a small auxiliary table ("Minor Table for the individual years"). It is divided into two parts: "Leap year" (Bissextilis) on the left, and "First [year] after the leap year" (Primus post bisext.) on the right. Each part lists, for years 1–3, the hours (H.), minutes (M.), and an instruction to add (Adde) or subtract (Subtrahe).

Leap year (Bissextilis):

An.	H.	M.	Instruction
1	5	49	Add (Adde)
2	11	37½	Add (Adde)
3	17	26	Add (Adde)

First [year] after the leap year (Primus post bisext.):

Anni	H.	M.	Instruction
1	5	49	Add (Adde)
2	11	37½	Add (Adde)
3	6	34	Subtract (Subtrahe)

REVOLUTIONS OF THE SUN — Libra through Pisces (Tabula Secunda, continued)

This page continues the Second Table with the remaining six signs — Libra ♎, Scorpio ♏, Sagittarius ♐, Capricorn ♑, Aquarius ♒, Pisces ♓ — again indexed by completed years in multiples of four.

A													A
n	♎	♎	♏	♏	♐	♐	♑	♑	♒	♒	♓	♓	n
ni	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	ni
4	0	44	0	43	0	42	0	42	0	43	0	44	4
8	1	28	1	26	1	24	1	24	1	26	1	29	8
12	2	12	2	9	2	7	2	7	2	9	2	13	12
16	2	56	2	51	2	49	2	49	2	52	2	58	16
20	3	41	3	34	3	31	3	31	3	35	3	42	20
24	4	25	4	17	4	13	4	13	4	19	4	26	24
28	5	9	5	0	4	55	4	55	5	2	5	11	28
32	5	53	5	43	5	37	5	37	5	45	5	55	32
36	6	37	6	26	6	20	6	20	6	28	6	40	36

A n ni	$\underline{\Omega}$ H.	$\underline{\Omega}$ M.	$\mathfrak{M}$ H.	$\mathfrak{M}$ M.	$\times$ H.	$\times$ M.	$\mathfrak{Y}$ H.	$\mathfrak{Y}$ M.	$\approx$ H.	$\approx$ M.	$\mathfrak{X}$ H.	$\mathfrak{X}$ M.	A n ni
6													6
4 0	7	21	7	9	7	2	7	2	7	11	7	24	4 0
4 4	8	5	7	52	7	44	7	44	7	54	8	8	4 4
4 8	8	49	8	34	8	26	8	26	8	37	8	53	4 8
5 2	9	33	9	17	9	9	9	9	9	20	9	37	5 2
5 6	10	17	10	0	9	51	9	51	10	3	10	21	5 6
6 0	11	2	10	43	10	33	10	33	10	46	11	6	6 0
6 4	11	46	11	26	11	15	11	15	11	29	11	50	6 4
6 8	12	30	12	9	11	57	11	57	12	12	12	35	6 8
7 2	13	14	12	52	12	40	12	40	12	56	13	19	7 2
7 6	13	58	13	34	13	22	13	22	13	39	14	3	7 6
8 0	14	42	14	17	14	4	14	4	14	22	14	48	8 0
8 4	15	26	15	0	14	46	14	46	15	5	15	32	8 4
8 8	16	10	15	43	15	28	15	28	15	48	16	17	8 8
9 2	16	54	16	25	16	11	16	11	16	31	17	1	9 2
9 6	17	38	17	9	16	53	16	53	17	14	17	45	9 6
1	18	23	17	52	17	35	17	35	17	57	18	30	1

A													A
n	☐	☐	℥	℥	⌘	⌘	☿	☿	♊	♊	♋	♋	n
ni	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	ni
0													0
0													0

INTERMEDIATE YEARS (Annis Intermediis)

The lower panel here is headed "Intermediate Years," divided into "Second [year] after the leap year" (Secundus post bisext.) on the left and "Third [year] after the leap year" (Tertius post bisext.) on the right. Each part lists years 1–3 with hours (H.), minutes (M.), and an add/subtract instruction.

Second [year] after the leap year (Secundus post bisext.):

Anni	H.	M.	Instruction
1	5	49	Add (Adde)
2	12	22½	Subtract (Subt.)
3	6	34	Subtract (Subt.)

Third [year] after the leap year (Tertius post bisext.):

Anni	H.	M.	Instruction
1	18	11	Subtract (Subtr.)
2	12	22½	Subtract (Subtr.)
3	6	34	Subtract (Subtr.)

On the Use of the Preceding Tables (Usus praecedentium Tabularum)

If the radix [base value] of any entry [ingressus] is known, as it is set out in the first table — for the beginnings of the three centuries with respect to the individual signs — then look up the completed years for which you want the restitution of the Sun in the First Table of Revolutions, using a double entry if they exceed the number of 20 years. Under the appropriate sign you will find the numbers of hours and minutes that must always be added to the time of the radix, so that the hour and minute of the restitution may be established. Always discard 24 hours (if this can be done) as superfluous, and keep the day nearest to the radix. You may also make a check of this from the computed place of the Sun.

The next table will do the same thing, and it will confirm — by repeating the operation — the day no less than the hour and minute of the revolution, provided you follow this procedure. If the completed years to be revolved can be divided by 4 with no remainder, use just this very table, and subtract the hours and minutes corresponding to the completed years (under the proper sign) from the time of the radix; for in this way the moment of the revolution will easily be established. But if any remainder is left beyond the division by four, the table set out below will be needed. Therefore check whether the year of the radix is a leap year, or which one it is in number after the intercalary [year]; and then, all the same, enter the upper table with the last years that can be divided by four, collecting the hours and the fractions corresponding to them. For the remainder, however — which is always 1, 2, or 3 — consult the other lower table, with this precaution. If the radix is a leap year, look at that part which has the title "Leap year" (*Titulum Anni bissextilis*). But where it is the first, second, or third after the leap year, then look likewise at the numbers written below the same titles, and taking from the side your year over and above the division by four, you will find the hours with the minutes to be added or subtracted, as the letter [i.e. the noted instruction] indicates.

If they are subtractive values, add them to the earlier subtractive values that applied to the quaternary years, and then subtract the sum from the time of the radix. But if they are of a different kind [i.e. one additive, one subtractive], subtract the smaller from the larger, and — following the sign of the prevailing number — add it to, or subtract it from, the radix time. In this way you will produce the true time of the revolution, accurately matching the beginnings of the signs. For although the lower and lesser table is arranged only to the mean annual quantity, which we assume beyond whole days to be 5 h. 48' 45", and therefore does not satisfy exactly at every beginning of the signs — especially at those that lie near each tropic, where the Sun's apogee and perigee are in the vicinity — nevertheless, since the largest difference, which can occur in Cancer ♋ and Capricorn ♎, scarcely exceeds two minutes even in the third year after any leap year, no appreciable inconvenience is introduced in this respect. I therefore did not wish to expand this table to all the signs, since that would have to be done otherwise — at greater length than the task is worth.

It must be noted, however, that everything I have said about the revolutions, drawn from the tables, in the Sun's motion, can be examined more accurately — and, as the need arises, refined — should anyone require greater precision in these matters. To be sure (as I would put it, to state the fact), to investigate and determine this very thing is more difficult and intricate than one might suppose,

since the observations of the ancients, which would have been of the greatest help here, do not agree among themselves. As for what Hipparchus [Hipparchus] handed down — and it is likely that he attended to such things more carefully than the rest — beyond a quarter of a day, the few intervening years are inconsistent and do not establish anything; so to matters that are still doubtful I will add nothing further.

This much, however, I judge can be gathered both from Hipparchus and from other very ancient authorities: that the true quantity of the equinoctial year, considered universally, comes as close as possible to 49 minutes beyond the days and hours found — only a few minutes are wanting here and there, and these are of scarcely any moment. On this matter I shall explain my view more fully elsewhere, having for now set aside that excessive irregularity of the solar year which is thought to underlie the less accurate observations of more recent astronomers, owing to the inaccuracies of those who came before.

One thing I do wish to add: that anyone who has fitted the revolutions, in the manner prescribed, to suitable years — especially these years nearest our own — will find greater certainty in them than if he were to use any other method whatever; so much so that the Copernican calculation [calculus Copernicaeus] here departs more widely than the Alphonsine. This the *Directions* alone, when properly carried out, will make plain, since for the individual days in a revolution — taken, as it were, for the annual interval within the Radix [radix] itself — they take the Sun's daily motion as it then is, measured in place: namely, according to Ptolemy [Ptolemy] a whole degree precisely, as Experience has taught us, while according to the opinion of certain more recent writers the simple daily motion of the Sun is assumed to be 59' 8", which is by no means constant. But concerning these matters, since they belong to Astrology rather than to Astronomy, this is not the place to treat at greater length.

This much, then, concerning the Sun, as we have now set it out, will be enough to have presented in the meantime. Elsewhere, God willing, we shall give a fuller and more general account.

[Margin: Notandum vero — extends across the upper portion of the page]

This at least now remains: that we should append a new table of the equation of natural days [aequatio dierum naturalium], insofar as the basis of the Apogee [Apogee] and Eccentricity [Eccentricity] in our reckoning requires it for the Sun in this present age.

Its use is as follows. Entering with the sign and degree of the Sun's true place, take out at their common intersection the minutes of time, which — according to the letters A and S there assigned — are to be added to, or subtracted from, the apparent time, so that it may be made equal [time]. Conversely, by proceeding the other way, if equal time is to be converted into apparent time [the procedure is reversed].

Table. Table of the equation of natural days. The twelve zodiacal sign symbols head the columns (Aries ♈, Taurus ♉, Gemini ♊, Cancer ♋, Leo ♌, Virgo ♍, Libra ♎, Scorpio ♏, Sagittarius ♐, Capricorn ♑, Aquarius ♒, Pisces ♓). Beneath each sign symbol is a row of letters indicating add/subtract (S = subtract for most signs; A appears for the last two signs). The next sub-header row reads "M" (minutes) under each sign. The leftmost column "Gr." gives the degree argument (2, 4, 6 ... 30).

Gr.	♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	A/M	A/M
2 0	9	12	6	2	6	16½	24	21	7	5	7	
4 1	9½	11	6	2	7	17	24	20	6	6	7	
6 1	10	11	5½	2	7	18	24	19½	5	6	7	
8 2	10	11	5	2	8	18	24½	19	4	6½	6½	
1 3	11	11	5	2	9	19	24	18	3½	7	6	
0												
1 3	11	10	4	2	9	20	24	17	2½	7	6	
2												
1 4	11	10	4	3	10	20	24	16	2	7½	5	
4												
1 5	11	10	3½	3	11	21	24	15	1	8	5	
6												
1 5	11½	9	3	3	11½	21	24	14	0	8	4	
8												
2 6	12	9	3	3	12	22	23½	13½	1 A	8	4	
0												
2 6	12	8½	3	4	13	22	23	12½	2	8	3	
2												
2 7	12	8	2½	4	13½	23	23	11½	3	8	2½	

G												
r	♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
.	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	S/M	A/M	A/M
4												
2	7½	12	8	2	5	14	23	22	10½	3	8	2
6												
2	8	12	7	2	5	15	23	22	9½	4	8	1
8												
3	8½	12	7	2	6	16	24	21	8½	5	7½	[?]
0												

[The left-margin running gloss alongside the table repeats the surrounding prose; it reads:] "This at least now remains, that we should append a new table of the equation of natural days, insofar as the basis of the Apogee and Eccentricity in our reckoning requires it for the Sun in this present age. Its use is: entering with the sign and degree of the Sun's true place, take out at their common intersection the minutes of time, which — according to the assigned letters A and S — are to be added to or subtracted from the apparent time, so that it may be made equal. By proceeding in the contrary manner, if apparent time is to be reckoned into equal time."

DE LUNAE MOTU RESTITUTO

APPENDIX

[On the Restored Motion of the Moon — Appendix]

The Moon, the other luminary, holding among the celestial bodies the rank second after the Sun, measures out the months just as the Sun measures the years; and it claims for itself very many further powers in the nature of things, about which it would now be far too lengthy to speak. And so, since the Moon is, as it were, the Sun's companion, and maintains with it a great familiarity and correspondence — both in other respects and especially in motion and appearances — and since, moreover, it contributes a great deal to having its motions worked out to the last detail, I judged it worth my while, if I were to add as an appendix to this chapter on the Sun (on which the Moon too depends) a brief and concise restoration of the lunar course, once I had explored the matter sufficiently through the accurate observations of many years. For its celestial phenomena do not agree with the hypotheses hitherto established, whether

Ptolemaic or Copernican, however the numbers may somehow be derived from them — and that not only with respect to Longitude, but also Latitude.

For in both of these is found a far greater complication and variety of apparent inequality than has hitherto been noticed by anyone. That this is so is plainly attested — to say nothing of Eclipses very often eluding the received canons by more than a whole hour (as regards the magnitude of the eclipses themselves, which sometimes presents itself otherwise, I say nothing) — by still greater discrepancies occurring in other positions, as both this and other points will show from our own restoration, when it is compared with the heavens themselves

Table. "Twenty-one Eclipses of the Moon and Nine of the Sun Diligently Observed by Us." The table is set in three panels enclosed in a ruled frame: two lunar-eclipse panels (left and upper-right) and one solar-eclipse panel (lower-right). Column headers: ANNI (year), MEN. (month), DIES (day), H. M. (hours, minutes), DIGI. (digits of obscuration).

ECLIPSES LUNAE (left panel):

Anni	Men.	Dies	H.	M.	Digi.
1573	Dece.	8	8	3	totalis
1576	Octob.	7	11	32	nōpat:
1577	April.	2	8	50	totalis
1577	Septe.	26	13	3	totalis
1578	Septe.	15	13	17	2½
1580	Ianu.	31	10	9	totalis
1581	Ianu.	19	9	57	totalis
1581	Iul.	15	16	57	totalis
1584	Nou.	7	13	12	totalis
1587	Sept.	6	9	16	9 45
1588	Mart.	2	15	2	totalis
1590	Dece.	30	6	55	nōpat:
1592	Iunij	14	10	16	8 0
1592	Dece.	8	7	41	nōpat:
1594	Octo.	19	19 26		nōpat:
1595	April.	13	16	36	totalis

ECLIPSES LUNAE (upper-right panel):

Anni	Men.	Dies	H.	M.	Digi.
1595	Octob	7	20	29	totalis
1596	April.	2	9	29	nōpat:
1598	Feb.	9	18	7	11 30
1598	Augu.	6	7	37	totalis
1599	Ianu.	30	17	50	totalis

ECLIPSES SOLIS (lower-right panel):

Anni	Men.	Dies	H.	M.	Digi.
1567	April.	9	0	0	6 20
1579	Febr.	25	5	50	5 50
1584	April.	30	5	39	3 0
1590	Iulij	21	7	54	5 0
1591	Iulij	10	3	33	2 30
1595	Septe.	23	1	8	3 50
1598	Feb.	24	23	16	9 20
1599	Iuli.	11	16	8	3 0
1600	Iun.	30	1	44	5 0

[printed p. 115 — recto]

with the heavens themselves and the calculations of others, these things will become plain. But in this place I shall touch as briefly as possible only on what is chiefly useful here and most necessary, intending to set forth a fuller treatment of the Moon as well in its own time, God willing.

Accordingly, the preceding pages having sent ahead [premised], I shall present several observations of Eclipses made by me within 27 years, with all the diligence that could be exercised, on which the theory of the lunar motion rests for the greater part, and as far as its more fundamental aspects are concerned.

From so many Eclipses — for not even three lunar ones suffice, as all practitioners hitherto have supposed, to restore exactly the simple motions of the Moon and its first inequality, and, in addition, where the need arose, the other observations required having been employed — the simple daily motions thus arise, derived from a comparison made with our own findings starting from Ptolemy's Epoch.

[Table of mean motions]

| | S | I | II | III | IV | V | VI | VII | VIII | IX | X |
 |---|---|---|---|---|---|---|---|---|---|---|---| | Longitude $\bowtie$ from $\odot$ | 12 | 11 | 26 |
 41 | 32 | 0 | 27 | 13 | 0 | 40 | 35 | | Anomaly | 13 | 3 | 53 | 56 | 20 | 41 | 41 | 51
 | 25 | 15 | 32 | | Latitude | 13 | 13 | 45 | 39 | 31 | 33 | 1 | 58 | 12 | 49 | 56 |

Annual	S	I	II	III	IV	V
Longitude	9	37	22	39	43	
Anomaly	2 28	43	7	45	54	
Latitude	4 28	42	45	26	56	

From these, the epochs reckoned back to the time of Christ are found, for the meridian of the first of January:

	S	I	II	III
Longitude	7	6	14	57
Anomaly	7	4	22	56
Latitude	7	16	50	42

From these the remaining numbers afterward entered into the canons [tables] have been composed.

HYPOTHESIS LUNAE REDINTEGRATA

[The Restored Hypothesis of the Moon]

Diagram. A geometric diagram of Brahe's restored lunar hypothesis. It consists of a large outer circle with a vertical diameter running top to bottom. Near the top of the figure sits a cluster of three nested small circles (the epicyclic apparatus); near the bottom, centered on the vertical axis, is a single small circle. The construction shows the Earth, an eccentric center, and the epicycle-on-epicycle arrangement described in the text below.

- M (top of upper cluster): outermost point of the small epicycle
- N (upper-left of small epicycle): epicycle circumference point
- L (upper-right of small epicycle): epicycle circumference point
- G (within upper cluster, near M): point on the inner small circle
- K (center of the middle circle of the upper cluster): center of the epicyclic carrier

- $\oplus$ (center of the upper main circle, marked with the Earth-cross symbol): the Earth's center, A
- O (left of the upper main circle): point on the eccentric/deferent circle
- H (right of the upper main circle): point on the eccentric/deferent circle
- T (lower point of the upper main circle, on the vertical axis): point on the circle
- C (on the vertical axis, just above the lower small circle): point of maximum distance from Earth
- E (left of the lower small circle): circumference point
- B (center of the lower small circle): the eccentric center
- D (right of the lower small circle): circumference point
- A (bottom of the lower small circle, on the vertical axis): the Earth, center of the universe
- 7 (at the very bottom of the large outer circle, on the axis): [figure-label numeral, or possibly the digit marking the foot of the diameter] [?]

[Margin numeral / register mark at right: 10]

EXPLICATIO HYPOTHESEOS

[Explanation of the Hypothesis]

Let A be the Earth, the center of the universe. Taking B as a center outside the Earth, there is described from it a small circle passing through the Earth's own center A, on which the center of the Eccentric F P R Q moves in such a way that at every conjunction ($\odot$) and opposition ($\oslash$) it lies truly at A. From there it ascends, with the elongation of the Moon doubled, to the true place — the Sun's place corrected by the epicyclic prosthaphaeresis [prosthaphaeresis] — through D, so that in every quadrature it is thus equalized at C, where it is found at its greatest distance from the Earth.

But since the Moon's Anomaly cannot be accounted for by the Eccentric together with the Epicycle, we have assumed, besides these two, yet another small circlet, whose center moves on the circumference of the first in such a way that, when the Moon is at apogee, it is found at G, and thus, descending through L H, and passing through perigee at I, it ascends again, until, one full revolution of the Anomaly being completed — which in the individual

taking place every 27 days, 13 hours, 18' 35", so that the Moon again comes to be at the apogee G. On this assumed small circle the body of the Moon is carried in such a way that, when the center of this small circle is at the apogee G, the Moon

will be at K, the point nearest to the center of the first epicycle. The motion of this small circle, moreover, runs in the opposite sense and is double the motion of the first; and it completes one revolution in 13 days, 18 h, 39' 17", with [an excess of?] 30". Hence, when the center of that small circle is at its mean position between G and I — that is, near H or O — then the Moon itself is found at M, at its greatest elongation from the center of the first epicycle.

But once we had tested these matters through many careful observations, we found that these circles did not yet satisfy all the appearances. For at the octants, that is, at the positions midway between the quadratures and the syzygies (conjunction $\oslash$ and opposition $\oslash^o$), when the two luminaries are a sign and a half apart from each other, a certain residual inequality and a quite perceptible discrepancy still showed itself. It therefore seemed necessary to add yet another small circle to account for this variation — one in which the center of the larger epicycle is carried not on the circumference but along the transverse diameter, by a kind of librating motion (a circular one, however, in the manner Copernicus elsewhere employs by analogy). This motion shifts the center back and forth, producing a certain prosthaphaeresis that must always be *added* from the conjunction $\oslash$ and opposition $\oslash^o$ of the luminaries up to the quadratures, and again *subtracted* from the quadratures back to conjunction $\oslash$ or opposition $\oslash^o$, [measured] from the mean longitude of the Moon $\textcircled{M}$ relative to the Sun $\textcircled{S}$ — so that the true place of the center of the epicycle may come out correctly.

This librating motion, moreover, is commensurate with the double of the true distance between the Sun $\textcircled{S}$ and the Moon $\textcircled{M}$, and it generates its greatest variation, 40' 30", to be *added* at the first and third octants from conjunction $\oslash$, and to be *subtracted* at the second and fourth octants — just as is sufficiently clear from the table of prosthaphaereses. And this is the construction of the lunar motions, derived from the appearances themselves on a circular basis. It can nevertheless be transformed in various ways, so that all those small circles may be arranged either *above*, next to the circumference of the lunar orbit; or *below*, next to the center; or *partly above and partly below* — which last arrangement we adopt here. The proportions of these orbs to one another are as follows: such that, the radius of the eccentric AF being 100000, FG will be 5800, GM 2900, and BA 2174. Finally, the small circle at F need not be measured otherwise than by the arc of 40' 30" that it subtends, since at so small a scale the difference is imperceptible.

From this stated dimension of the orbs, the angle of the first inequality — the greatest one, which occurs at the new and full moons — comes out to 4° 58' with a

half [i.e. 4° 58' 30"], falling imperceptibly short of the Ptolemaic value. The greatest of all, however, occurs at the quadratures: 7° 28' — which is less by a fifth part of a degree than the value Ptolemy assumed, retained by both Alphonsus [Alfonso X] and Copernicus.

DE AEQUATIONE TEMPORIS RESPECTU MOTUS LUNARIS.

[On the Equation of Time with respect to the Lunar Motion.]

Experience, applied in many ways, attests that the equal motions of the Moon do not conform to the same equation of natural days that the Sun produces — except insofar as the Moon's motion depends on the Sun's true motion, in which respect that difference is, as it were, absorbed. We have therefore devised another method and table for the equation of time, by which we reduce [the apparent motion] to the Moon; it is constructed from the right ascensions of the degrees of the ecliptic, and stands as follows.

The use of the table is this: entering with the sign and degree of the place of the Sun (descending or ascending, according as the sign is found at the head or at the foot of the table), the minutes and seconds that the area [of the table] displays for the apparent time are to be added or subtracted according to the requirement of the heading, so that equal [time] may be produced. Conversely, one should proceed in the opposite manner if equal time is to be reduced to apparent.

Table of the Equation of Time.

The table is a single grid keyed to the zodiac signs. The three paired-sign column blocks are headed at the top (read descending) with the sign symbols: ♈ ♌ || ♉ ♍ || ♊ ♏, and at the foot (read ascending) with ♋ ♏ [recte: see note] || ♌ ♎ || ♍ ♏ [?]. Each block is labeled **S** (signum) at the head and **A** (additio/subtractio marker) at the foot, with two value sub-columns headed **M** (minuta) and **S** (secunda). The leftmost column is the degree argument (0–30).

Degr ee	♈/♌ M	♈/♌ S	♉/♍ M	♉/♍ S	♊/♏ M	♊/♏ S	Degree (foot)
0 (c)	0	0	8	25	8	47	30
1	0	20	8	36	8	37	29
2	0	40	8	45	8	26	28
3	0	59	8	55	8	15	27
4	1	19	9	4	8	3	26

Degr ee	♈/♊ M	♈/♊ S	♉/♋ M	♉/♋ S	♊/♌ M	♊/♌ S	Degree (foot)
5	1	39	9	12	7	50	25
6	1	59	9	19	7	36	24
7	2	18	9	26	7	22	23
8	2	38	9	32	7	7	22
9	2	57	9	37	6	52	21
10	3	16	9	42	6	36	20
11	3	35	9	46	6	20	19
12	3	53	9	50	6	3	18
13	4	12	9	52	5	46	17
14	4	30	9	54	5	28	16
15	4	47	9	56	5	10	15
16	5	5	9	56	4	51	14
17	5	22	9	56	4	32	13
18	5	38	9	55	4	12	12
19	5	55	9	53	3	53	11
20	6	11	9	51	3	33	10
21	6	26	9	48	3	12	9
22	6	41	9	44	2	51	8
23	6	56	9	40	2	31	7
24	7	10	9	34	2	9	6
25	7	24	9	28	1	48	5
26	7	37	9	21	1	27	4
27	7	50	9	14	1	5	3
28	8	2	9	6	0	43	2
29	8	14	8	57	0	22	1
30	8	25	8	47	0	0	0

Foot-of-table sign symbols (ascending entry): ♈ ♊ || ♉ ♋ || [?] ♌.

Epochs of the Mean Motions of the Moon — Collected Years.

Column blocks: **Anni Completi** (completed years) | **Longitudo** ♃ to ☉ (Longit. ♃ d ☉), with sub-columns **S G M S** (signa, gradus, minuta, secunda) | **Anomalía**,

sub-columns **S G M S** | **M. Latitudinis** (mean of latitude / argument of latitude),
sub-columns **S G M S**.

In Collected Years (IN ANNIS COLLECTIS):

Ye a r	Lon				Ano		Ano		Lat.			
	g. S	g. G	g. M	g. S	m. S	m. G	m. M	m. S	S	G	M	S
1400	6	15	9	26	3	23	28	46	9	24	47	31
1420	10	28	34	13	5	3	10	51	3	5	11	28
1440	3	11	58	59	6	12	52	56	8	15	35	26
1460	7	25	23	46	7	22	35	1	1	25	59	23
1480	0	8	48	33	9	2	17	6	7	6	23	20
1500	4	22	13	19	10	11	59	11	0	16	47	17
1520	9	5	38	6	11	21	41	16	5	27	11	15
1540	1	19	2	53	0	1	23	21	11	7	35	12

Year	Longitude S	Longitude G	Longitude M	Longitude S	Longitude S	Longitude G	Longitude M	Longitude S	Longitude G	Longitude M	Longitude S	Longitude G	Longitude M	Longitude S
540														

Expanded Years (IN ANNIS EXPANSIS):

Year	Longitude S	Longitude G	Longitude M	Longitude S	Longitude S	Longitude G	Longitude M	Longitude S	Longitude G	Longitude M	Longitude S	Longitude G	Longitude M	Longitude S
1560	6	2	27	40	2	11	5	26	4	17	59	9		
1561	10	12	5	2	5	9	48	33	9	16	41	55		
1562	2	21	42	25	8	8	31	41	2	15	24	40		
1563	7	1	19	48	11	7	14	49	7	14	7	26		
1564	11	23	8	37	2	13	1	51	0	26	3	57		
1565	4	2	45	59	5	17	44	57	5	24	46	42		

Y e a r	Ano							Ano m. M	Ano m. S	Lat. S	Lat. G	Lat. M	Lat. S
	Lon g. S	Lon g. G	Lon g. M	Lon g. S	Ano m. S	Ano m. G							
1 5 6 6	8	12	23	22	8	16	28	5	10	23	29	28	
1 5 6 7	0	22	0	45	11	15	11	13	3	22	12	13	
1 5 6 8	5	13	49	34	2	26	58	16	9	4	8	44	
1 5 6 9	9	23	26	57	5	25	41	23	2	2	51	30	
1 5 7 0	2	3	4	19	8	24	24	31	7	1	34	15	
1 5 7 1	6	12	41	42	11	23	7	39	0	0	17	0	
1 5 7 2	11	4	30	31	3	4	54	40	5	12	13	32	
1 5 7 3	3	14	7	54	6	3	37	48	10	10	56	17	
1	7	23	45	17	9	2	20	56	3	9	39	2	

Year	Longitude S	Longitude G	Longitude M	Longitude S	Longitude S	Longitude G	Longitude M	Longitude S	Longitude G	Longitude M	Longitude S	
1954	0	3	22	39	0	1	4	4	8	8	21	48
1957	4	25	11	29	3	12	51	5	1	20	18	19
1957	9	4	43	51	6	11	34	13	6	19	1	4
1957	1	14	26	14	9	10	17	21	11	17	43	50

Epochs of the Mean Motions of the Moon — Expanded Years, continued.

Same column structure: **Anni Completi** | **Longit.** $\supset \mathbf{d} \odot (\text{S G M S})$ | **Anomalia** (S G M S) | **M. Latitudinis** (S G M S).

Year	Long. S	Long. G	Long. M	Long. S	Anom. S	Anom. G	Anom. M	Anom. S	Lat. S	Lat. G	Lat. M	Lat. S
1957	5	24	3	37	0	9	0	29	4	16	26	35
1951	10	15	52	26	3	20	47	30	9	28	23	6

Y e a r	Ano							Ano m. M	Ano m. S	Lat. S	Lat. G	Lat. M	Lat. S
	Lon g. S	Lon g. G	Lon g. M	Lon g. S	Ano m. S	Ano m. G							
8 0													
1 5 8 1	2	25	29	49	6	19	30	38	2	27	5	52	
1 5 8 2	7	5	7	11	9	18	13	46	7	25	48	37	
1 5 8 3	11	14	44	34	0	16	56	54	0	24	31	23	
1 5 8 4	4	6	33	24	3	28	43	56	6	6	27	54	
1 5 8 5	8	16	10	47	6	27	27	3	11	5	10	39	
1 5 8 6	0	25	48	9	9	26	10	11	4	3	53	25	
1 5 8 7	5	5	25	32	0	24	53	19	9	2	36	10	
1 5 8	9	27	14	21	4	6	40	20	2	14	32	41	

[illegible]

Y e a r	Ano							Ano m. M	Ano m. S	Lat. S	Lat. G	Lat. M	Lat. S
	Lon g. S	Lon g. G	Lon g. M	Lon g. S	Ano m. S	Ano m. G							
1 5 9 7	1	18	13	39	7	21	16	18	11	29	25	2	
1 5 9 8	5	27	51	1	10	19	59	26	4	28	7	47	
1 5 9 9	10	7	28	24	1	18	42	34	9	26	50	33	
1 6 0 0	2	29	17	13	5	0	29	35	3	8	47	4	
1 6 0 1	7	8	54	36	7	29	12	43	8	7	29	49	
1 6 0 2	11	18	31	59	10	27	55	51	1	6	12	35	
1 6 0 3	3	28	9	21	1	26	38	59	6	4	55	20	
1 6 0 4	8	19	58	11	5	8	26	0	11	16	51	51	
1	0	29	35	33	8	7	9	8	4	15	34	37	

Y e a r	Lon g. S	Lon g. G	Lon g. M	Lon g. S	Ano m. S	Ano m. G	Ano m. M	Ano m. S	Lat. S	Lat. G	Lat. M	Lat. S
6 0 5 1 6 0 6	5	9	12	56	11	5	52	16	9	14	17	22

Epochs of the Mean Motions of the Moon [Epochae aequalium motuum Lunae]

Each table is divided into three column-groups, each given in signs / degrees / minutes / seconds (S | G | M | S):

- **Longitude of the Moon from the Sun** [Longit. ☽–☉ S]
- **Anomaly** [Anomalial]
- **mean of Latitude** [M. Latitudinis]

The argument column is headed **Anni Compl(eti)** [Anni Cōple — completed years].

EPOCHS OF THE MEAN MOTIONS OF THE MOON [EPOCHAE AEQUALIUM MOTUUM LUNAE]

For the Expanded Years [In Annis Expansis]

Yea r	Longit. ☽–☉ S	Anom.				M. Lat. S			
		G	M	S	S	G	M	S	S
160 7	9	1	5	1	2	4	3	2	2
		8	0	9		5	4		3
160 8	2	1	3	8	5	1	2	2	7
		0	9			6	2	5	
160 9	6	2	1	3	8	1	5	3	0
		0	6	1		5		3	

Yea		Anom.																	
r	Longit. ☽-☉ S	G	M	S	S	G	M	S	M. Lat. S	G	M	S		G	M	S			
161	10	2	5	5	11	1	4	4	5	2	2	1							
0		9	3	3		3	8	1		2	2	0							
161	3	9	3	1	2	1	3	4	10	2	4	5							
1			1	6		2	1	9		1		5							
161	8	1	2	5	5	2	1	5	4	3	1	2							
2			0			4	8	0				6							
161	0	1	5	2	8	2	1	5	9	1	4	1							
3		0	7	8		3		8			4	2							
161	4	2	3	5	11	2	4	6	2	0	2	5							
4		0	4	1		1	5				6	7							
161	9	0	1	1	2	2	2	1	6	2	9	4							
5			2	3		0	8	4		9		2							
161	1	2	1	3	6	2	1	1	0	1	6	1							
6		2					5	5		1		4							
161	6	1	3	2	9	0	5	2	5	9	4	5							
7			8	5			8	3			8	9							
161	10	1	1	4	11	2	4	3	10	8	3	4							
8		1	5	8		9	1	1			1	4							
161	2	2	5	1	2	2	2	3	3	7	1	3							
9		0	3	1		8	4	9			4	0							
162	7	1	4	0	6	1	1	4	8	1	1	1							
0		2	2			0	1	0		9	1								
162	11	2	1	2	9	8	5	4	1	1	5	4							
1		2	9	3			4	8		7	3	6							
162	4	1	5	4	0	7	3	5	6	1	3	3							
2			6	5			7	6		6	6	2							
162	8	1	3	8	3	6	2	4	11	1	1	1							
3		1	4				1			5	9	7							
162	1	3	2	5	6	1	8	5	4	2	1	4							
4			2	7		8				7	5	8							
162	5	1	0	2	9	1	5	1	9	2	5	3							
5		3		0		6	1	3		5	8	4							
162	9	2	3	4	0	1	3	1	2	2	4	1							

Yea		Anom.																	
r	Longit.	☽	☉	S		G	M	S	S		G	M	S	M. Lat.	S		G	M	S
6						2	7	2			5	4	1				4	1	9
162	2					2	1	5	3		1	1	2	7			2	2	5
7							5				4	7	9				3	4	
162	6					2	3	5	6		2	4	3	1			5	2	3
8						4		4			6		0					0	6
162	11					3	4	1	9		2	4	3	6			4	3	2
9							1	7			4	7	8						1
163	3					1	1	4	0		2	3	4	11			2	4	7
0						3	8	0			3	0	6					6	
163	7					2	5	2	3		2	1	5	4			1	2	5
1						2	6				2	3	4					8	2
163	0					1	4	5	7		4	0	5	9			1	2	2
2						4	4	2					5				3	5	3
163	4					2	2	1	10		2	4	3	2			1	8	9
3						4	2	4				4					2		
163	9					3	5	3	1		1	2	1	7			1	5	5
4							9	7				7	1				0	0	4
163	1					1	3	5	4		0	1	1	0			9	3	4
5						3	6	9				0	9					3	0
163	6					5	2	4	7		1	5	2	5			2	3	1
6							5	9			1	7	0				1	0	1
163	10					1	3	1	10		1	4	2	10			2	1	5
7						5		2			0	0	8				0	2	6
163	2					2	4	3	1		9	2	3	5			1	5	4
8						4	0	4				3	6				8	5	2
163	7					4	1	5	4		8	6	4	8			1	3	2
9							7	7					4				7	8	7
164	11					2	6	4	7		1	5	4	1			2	3	5
0						6		6			9	3	5				9	4	8
164	4					5	4	9	10		1	3	5	6			2	1	4
1							4				8	6	3				8	7	4
164	3					1	2	3	1		1	2	1	11			2	0	2
2						5	1	2			7	0					7		9

Yea		Anom.																	
r	Longit. ☽-☉ S	G	M	S	S	G	M	S	M. Lat. S	G	M	S		G	M	S			
164	0	2	5	5	4	1	3	9	4	2	4	1							
3		4	8	4		6				5	3	5							
164	5	1	4	4	7	2	5	1	10	7	3	4							
4		6	7	4		7	0	0		9	6								
164	9	2	2	6	10	2	3	1	3	6	2	3							
5		6	5			6	3	8		2	1								
164	2	6	2	2	1	2	1	2	8	5	5	1							
6				9		5	6	6				7							
164	6	1	3	5	4	2	5	3	1	3	4	2							
7		5	9	2		3	9	4		8									
164	11	7	2	4	8	5	4	3	6	1	4	3							
8			8	1			6	5		5	4	3							
164	3	1	6	4	11	4	2	4	11	1	2	1							
9		7					9	3		4	7	9							
165	7	2	4	2	2	3	1	5	4	1	1	4							
0		6	3	6			2	1		3	0								
165	0	6	2	4	5	1	5	5	9	1	5	5							
1			0	9			5	9		1	2	0							
165	4	2	9	3	8	1	4	0	2	2	4	2							
2		8		8		3	3			3	9	1							
165	9	7	4	1	11	1	2	8	7	2	3	6							
3			7			2	6			2	2								
165	1	1	2	2	2	1	9	1	0	2	1	5							
4		7	4	4		1		6		1	4	2							
165	5	2	1	4	5	9	5	2	5	1	5	3							
5		7		6			2	4		9	7	7							
165	10	1	5	3	8	2	3	2	11	1	5	8							
6		8	0	5		1	9	5		4									
165	2	2	2	5	11	2	2	3	4	0	3	5							
7		8	7	8		0	2	3		6	4								
165	7	8	5	2	2	1	5	4	8	2	1	3							
8				1		9		1		9	9	9							
165	11	1	4	4	5	1	4	4	1	2	2	2							

Yea					Anom.											
r	Longit. ☽-☉ S				G	M	S	S	G	M	S	M. Lat. S	G	M	S	
9					7	2	3		7	8	9		8		4	
166	4					9	3	3	8	2	3	5	7	9	5	5
0						1	3			9	5	0			8	6

For the Collected Years [In Annis Collectis]

Ye	Anom										
ar	Longit. ☽-☉ S	G M S . S				G M S M. Lat. S				G	M S
16	8	2 5 2 10				9 1 5 0				20	2 5
80		2 6 0				7 5					2 3
17	1	6 2 6 11				1 0 0 6				0	4 5
00		1				9					6 0
17	5	1 4 5 0				2 4 5 11				11	1 4
20		9 5 3				3 2					0 7
17	10	3 1 4 2				8 2 1 4				21	3 4
40		0 0				4 0					4 5
17	2	1 3 2 3				1 6 1 10				1	5 4
60		6 5 6				8 5					8 2
17	7	0 0 1 4				2 4 2 3				12	2 3
80		3				7 8 0					2 9
18	11	1 2 0 6				7 3 2 8				7 [recte: 7?]	4 6
00		3 5				0 5					6

For the Single Years up to Twenty [In Annis Singulis usque ad Viginti]

Yea		Anom.											
r	Longit. ☽-☉ S	G	M	S	S	G	M	S	M. Lat. S	G	M	S	
1	4	9	3	2	2	2	4	8	4	2	4	4	
			7	3		8	3			8	2	5	
2	8	1	1	4	5	2	2	1	9	2	2	3	
		9	4	5		7	6	6		7	5	1	
3	0	2	5	8	8	2	9	2	2	2	8	1	
		8	2			6		3		6		6	

Yea		Anom.																	
r	Longit. ☽-☉ S	G	M	S	S	G	M	S	M. Lat. S	G	M	S		G	M	S			
4	5	2	4	5	0	7	5	2	8	8	4	4							
		0	0	7			6	5				7							
5	10	0	1	2	3	6	3	3	1	6	4	3							
			8	0			9	3			7	3							
6	2	9	5	4	6	5	2	4	6	5	3	1							
			5	3			2	1			0	8							
7	6	1	3	5	9	4	5	4	11	4	1	4							
		9	3					8			3								
8	11	1	2	5	0	1	5	5	4	1	9	3							
		1	1	5		5	2	0		6		5							
9	3	2	5	1	3	1	3	5	9	1	5	2							
		0	9	7		4	5	8		4	2	0							
10	8	0	3	4	6	1	1	6	2	1	3	6							
			6	0		3	9			3	5								
11	0	1	1	3	9	1	2	1	7	1	1	5							
		0	4			2		3		2	7	1							
12	5	2	2	5	0	2	4	1	0	2	1	2							
				2		3	9	5		4	4	2							
13	9	1	4	1	3	2	3	2	5	2	5	8							
		1	0	5		2	2	3		2	7								
14	1	2	1	3	6	2	1	3	10	2	3	5							
		1	7	7		1	5	1		1	9	3							
15	6	0	5	0	9	1	5	3	3	2	2	3							
			5			9	8	8		0	2	9							
16	10	2	4	4	1	1	4	4	9	2	1	1							
		2	3	9			5	0			9	0							
17	3	2	2	1	4	0	2	4	2	1	1	5							
			1	2			8	8				5							
18	7	1	5	3	6	2	1	5	6	2	4	4							
		1	8	5		9	1	6		9	4	1							
19	11	2	3	5	9	2	5	3	11	2	2	2							
		1	5	7		7	5			8	7	6							
20	4	1	2	4	1	9	4	5	5	1	2	5							

Year	Longit. ☽-☉ S	Anom.				M. Lat. S			
		G	M	S	S	G	M	S	S
		3	4	7		2			0 3 7

For the Months of the Common Year [In Mensibus Anni Communis]

Month	Longit. ☽-☉ S	G	Ano m. S	M. Lat. S
January [Ianuari]	0	17	1	1
February [Februari]	1	29	1	2
March [Martius]	0	17	3	3
April [Aprilis]	0	22	4	4
May [Majus]	1	10	5	6
June [Iunius]	1	16	6	7
July [Iulius]	2	4	8	9
August [August ⁿ]	2	22	9	11
September [Septēber]	2	28	10	0
October [October]	3	15	0	2
November [Novem]	3	41 [recte: 41?]	1	3
December [Decem]	4	9	2	4

For the Months of the Bissextile Year [In Mensibus Anni Bissextilis]

Month	Longit. ☽-☉ S	Anom				M. Lat.			
		G	M	S	S	G	M	S	S
January [Ianuari]	0	1	5	4	1	1	0	5	1
		7	4	7		5	2		
February [Februari]	0	1	2	4	2	3	5	5	2
		1	6	1		3	6		

Month	Longit. ☽-☉ S	Anom				M. Lat.			
		G	M	S	. S	G	M	S	G M S
March [Martius]	0	2	2	2	3	1	5	4	3 5 1
		9	1	9		8	4	9	2 6
April [Aprilis]	1	5	4	5	4	2	5	4	1 4 6
			0			0	1	7	0 5
May [Majus]	1	2	5	3	6	5	5	3	0 5 4
		2	9	7		2	9		1 1
June [Iunius]	1	2	4	5	7	7	4	3	7 4 3
		8	2	8		9	7		4 1
July [Iulius]	2	1	3	4	8	2	5	2	2 5 6
		6	7	5		2	0	9	7 1
August [Augu]	3	4	3	3	10	7	5	2	1 5 4
			2	3		1	2		7 7 1
September	3	1	1	5	11	9	4	2	2 5 3
[Septem]		0	5	3		8	0		4 0 1
October [October]	3	2	1	4	0	2	4	1	1 5 7
		8	0	1		4	9	2	4 7
November	4	3	5	2	1	2	4	1	2 4 5
[Novem]			4			6	6	0	1 9 7
December [Decem]	4	2	4	4	3	1	4	2	1 5 3
		1	8	9		1	7		1 6 3

For the Days [In Diebus]

D									
ay	Longit. ☽-☉ S	G	M	S	Anom. S	G	M	S	M. Lat. S
1	0	1	1	2	0	1	3	5	0
		2	1	7		3		4	
2	0	2	2	5	0	2	7	4	0
		4	2	3		6		8	
3	1	6	3	2	1	9	1	4	1
			4	0			1	2	
4	1	1	4	4	1	2	1	3	1
		8	5	7		2	5	6	
5	2	0	5	1	2	5	1	3	2

D	ay	Longit. ☽-☉ S	G	M	S	Anom. S	G	M	S	M. Lat. S	G	M	S
			7	3			9	0					8
6	2		1	8	4	2	1	2	2	2	1	2	3
			3		0		8	3	4		9	2	4
7	2		2	2	7	3	1	2	1	3	2	3	2
			5	0				7	8			6	0
8	3		7	3	3	3	1	3	1	3	1	5	5
				1	4		4	1	2		5	0	
9	3		1	4	0	3	2	3	5	3	2	3	5
			9	3			7	5			9		1
10	4		1	5	2	4	1	3	5	4	1	1	3
				4	7		0	8	9		2	7	7
11	4		1	5	5	4	2	4	5	4	2	3	2
			4		4		3	2	3		5	1	2

Mean Motions of the Moon — In Days (continued)

Mean Motions of the Moon, in Days [Medii Motus Lunae. In Diebus]

This table continues the by-days lunar mean motions begun on the preceding page, here running from day 12 through day 31. Three column-groups: Longitude of the Moon from the Sun [Long. ☽ à ☉], Anomaly [Anomalia], and the mean of Latitude [M. Latitudinis], each given in signs (S), degrees (G), minutes (M), and seconds (S).

D	a	L:	L:	L:	L:	An:	An:	An:	An:		Lat:		
y		S	G	M	S	S	G	M	S	Lat: S	Lat: G	M	Lat: S
1	2	4	26	17	20	5	6	46	47	5	8	45	8
1	3	5	8	28	47	5	19	50	41	5	21	58	54
1		5	20	40	14	6	2	54	35	6	5	12	39

D a y	L: S	L: G	L: M	L: S	An: S	An: G	An: M	An: S	Lat: S	Lat: G	Lat: M	Lat: S
4												
1	6	2	51	40	6	15	58	29	6	18	26	25
5												
1	6	15	3	7	6	29	2	23	7	1	40	11
6												
1	6	27	14	34	7	12	6	17	7	14	53	56
7												
1	7	9	26	0	7	25	10	11	7	28	7	42
8												
1	7	21	37	27	8	8	14	5	8	11	21	28
9												
2	8	3	48	54	8	21	17	59	8	24	35	13
0												
2	8	16	0	21	9	4	21	53	9	7	49	59
1												
2	8	28	11	47	9	17	25	47	9	21	2	44
2												
2	9	10	23	14	10	0	29	41	10	4	16	30
3												
2	9	22	34	41	10	13	33	35	10	17	30	16
4												
2	10	4	46	7	10	26	37	28	11	0	44	1
5												
2	10	16	57	34	11	9	41	22	11	13	57	47
6												
2	10	29	9	1	11	22	45	16	11	27	11	33
7												
2	11	11	20	27	0	5	49	10	0	10	25	18
8												
2	11	23	31	54	0	18	53	4	0	23	39	4
9												
3	0	5	43	21	1	1	56	58	1	6	52	50

D													
a	L:	L:	L:	L:	An:	An:	An:	An:				Lat:	
y	S	G	M	S	S	G	M	S	Lat: S	Lat: G	M	Lat: S	
0													
3	0	17	54	47	1	15	0	52	1	20	6	35	
1													

Row count: 20 rows (days 12–31). Bottom of grid reached (the table ends after day 31, followed by the printer's flower).

Mean Motions of the Moon — In Hours and Minutes

Mean Motions of the Moon, in Hours and Minutes [Medii Motus Lunae. In Horis et Minutis]

This is a double-panel table. The **left panel** is headed by hours (H) and gives, against each hour from 1 to 30, three quantities — Longitude of the Moon from the Sun [Longi. ☽ à ☉], Anomaly [Anomalia], and the mean of Latitude [M. Latitudinis] — each in degrees (G), minutes (M), and seconds (S). The sub-header row beneath reads minutes (Min.) over the hour column and M / S (with a "T" mark in the carry positions) over the value columns. The **right panel** continues the hours from 31 to 60, giving the same three quantities (Longit. / Anomalia / M. Latit.) in minutes (M) and seconds (S).

The within-hour values are small (degrees ≤ 30 in the left longitude column over the 30-hour span; minutes and seconds ≤ 59 throughout). Values are read off the native-resolution strips cell by cell.

Left panel (hours 1–30)

	Long:	Long:		Anom:	Anom:	Anom:		Lat:	
H	G	M	Long: S	G	M	S	Lat: G	M	Lat: S
1	0	30	29	0	32	40	0	33	5
2	1	0	57	1	5	19	1	6	10
3	1	31	26	1	37	59	1	39	14
4	2	1	54	2	10	39	2	12	19
5	2	32	23	2	43	19	2	45	23

H	G	Long:	Long:	Long: S	Anom:	Anom:	Anom:	Lat: G	Lat:	Lat: S
		M	M		G	M	S		M	
6	3	2	52	3	15	58	3	18	27	
7	3	33	20	3	48	38	3	51	32	
8	4	3	49	4	21	18	4	24	36	
9	4	34	18	4	53	58	4	57	41	
1	5	4	46	5	26	37	5	30	45	
0										
1	5	35	15	5	59	17	6	3	49	
1										
1	6	5	43	6	31	57	6	36	54	
2										
1	6	36	12	7	4	37	7	9	58	
3										
1	7	6	41	7	37	16	7	43	3	
4										
1	7	37	9	8	9	56	8	16	7	
5										
1	8	7	38	8	42	36	8	49	11	
6										
1	8	38	6	9	15	16	9	22	16	
7										
1	9	8	35	9	47	55	9	55	20	
8										
1	9	39	4	10	20	35	10	28	25	
9										
2	10	9	32	10	53	15	11	1	29	
0										
2	10	40	1	11	25	55	11	34	33	
1										
2	11	10	29	11	58	34	12	7	38	
2										
2	11	40	58	12	31	14	12	40	42	
3										
2	12	11	37	13	3	54	13	13	48	

	Long:	Long:		Anom:	Anom:	Anom:		Lat:	
H	G	M	Long: S	G	M	S	Lat: G	M	Lat: S
4									
2	12	42		13	37		13	47	
5									
2	13	12		14	9		14	20	
6									
2	13	43		14	42		14	53	
7									
2	14	13		15	15		15	26	
8									
2	14	44		15	47		15	59	
9									
3	15	14		16	20		16	32	
0									

Right panel (hours 31–60)

H	Long: M	Long: S	Anom: M	Anom: S	Lat: M	Lat: S
3	15	45	16	53	17	5
1						
3	16	15	17	25	17	38
2						
3	16	46	17	58	18	11
3						
3	17	16	18	31	18	44
4						
3	17	47	19	3	19	18
5						
3	18	18	19	36	19	51
6						
3	18	48	20	8	20	24
7						
3	19	19	20	41	20	57
8						
3	19	49	21	14	21	30

H	Long: M	Long: S	Anom: M	Anom: S	Lat: M	Lat: S
9						
4	20	19	21	46	22	3
0						
4	20	49	22	19	22	36
1						
4	21	20	22	51	23	9
2						
4	21	50	23	24	23	42
3						
4	22	21	23	57	24	15
4						
4	22	51	24	30	24	[numeral: ?]
5						
4	23	21	25	3	25	21
6						
4	23	52	25	35	25	54
7						
4	24	22	26	8	26	27
8						
4	24	53	26	41	27	0
9						
5	25	24	27	13	27	34
0						
5	25	54	27	46	28	7
1						
5	26	25	28	18	28	48
2						
5	26	55	28	51	29	13
3						
5	27	26	29	24	29	46
4						
5	27	56	29	56	30	19
5						
5	28	26	30	29	30	52

H	Long: M	Long: S	Anom: M	Anom: S	Lat: M	Lat: S
6						
5	28	57	31	1	31	25
7						
5	29	27	31	34	31	58
8						
5	29	58	32	7	32	31
9						
6	30	29	32	40	33	5
0						

Row count, hours table: 30 rows per panel (hours 1–30 left, 31–60 right); both bottoms reached.

Table of Lunar Prosthaphaereses — 0 Signs

Table of Lunar Prosthaphaereses [Tabula Prosthaphaeresium Lunarium] — 0 Signs [0 Signum]

This is the principal lunar equation table for the zodiacal argument 0 signs (0°–30°). The argument runs down the left edge from 0 to 30. The column-groups, with their printed operation rubrics, are:

- **Prosthaphaeresis of the epicycle [Prosth. Epic.] — Subtract [Subtrahe]**, in degrees (G), minutes (M), seconds (S).
- **Difference [Diffra] — Add [Adde]**, in minutes (M), seconds (S).
- **Elongation from Centre [Elô. à Cen.]** [a five-digit tabulated quantity, here near 102900].
- **Difference [Dif.] — Subtract [Sub.]** (the small integer argument-difference column).
- **Eccentric [Eccentrici] — (Subtract)** [a tabulated three- to four-digit quantity].
- **Difference [Dif.] — Add [Ad.]**, in minutes (M), seconds (S).
- **Variation [Variatio] — Add [Adde]**, in minutes (M), seconds (S).
- **Difference [Diffra] — Add [Adde]**, in minutes (M), seconds (S), with a descending complementary argument (30 → 0) in the far-right edge column.

The interleaving of the "difference" columns means several of them carry their own running argument index offset by half a row from the main argument; these are transcribed in the row where they print.

A	Ep	Ep	Ep	Di	Di		Dif	Ecc	Dif	V	V			Ar
r	ic	ic	ic	ff1	ff1	Elong	sub	ent	(A	a	a	Diff(A	Diff(A	g
g	G	M	S	M	S	à Cen	)	r	d)	M	S	dd) M	dd) S	↓
0	0	0	0			102900		0		0	0	0	43	30
1	0	5	4	5	4	102899	1	38	38	0	4	0	43	29
											3			
2	0	10	8	5	4	102898	1	76	38	1	2	0	42	28
											6			
				5	4		2		38			0	42	
3	0	15	12	5	4	102896	2	11	38	2	8	0	42	27
								4						
4	0	20	16	5	4	102894	2	15	38	2	5	0	42	26
								2			0			
5	0	25	20	5	3	102891	3	19	38	3	3	0	42	25
								0			2			
				5	3		3		38			0	42	
6	0	30	23	5	3	102888	4	22	37	4	1	0	42	24
								8			4			
7	0	35	26	5	3	102884	4	26	38	4	5	0	42	23
								5			6			
8	0	40	28	5	2	102879	5	30	38	5	3	0	42	22
								3			8			
9	0	45	29	5	1	102873	6	34	38	6	2	0	42	21
								1			0			
1	0	50	30	5	1	102867	6	37	38	7	2	0	42	20
0								9						
1	0	55	30	5	0	102860	7	41	38	7	4	0	42	19
1								7			4			
1	1	0	28	4	58	102853	7	45	37	8	2	0	42	18
2								4			6			
1	1	5	25	4	57	102845	8	49	38	9	7	0	41	17

A r g	Ep ic G	Ep ic M	Ep ic S	Di ff1 M	Di ff1 S	Elong à Cen	Dif (sub)	Ecc ent r	Dif (A d)	V a r M	V a r S	Diff(A dd) M	Diff(A dd) S	Ar g ↓
3								2						
1 4	1	10	21	4	56	102836	9	53 0	38	9	4 8	0	41	16
1 5	1	15	16	4	55	102826	10	56 8	38	1 0	2 9	0	41	15
1 6	1	20	10	4	54	102816	10	60 5	37	1 1	1 0	0	41	14
1 7	1	25	3	4	53	102805	11	64 3	38	1 1	5 1	0	41	13
1 8	1	29	55	4	52	102793	12	68 0	37	1 2	3 1	0	40	12
1 9	1	34	44	4	49	102781	12	71 8	38	1 3	1 1	0	40	11
2 0	1	39	32	4	48	102768	13	75 5	37	1 3	5 1	0	40	10
2 1	1	44	18	4	46	102755	13	79 2	37	1 4	3 1	0	40	9
2 2	1	49	3	4	45	102741	14	83 0	38	1 5	1 0	0	39	8
2 3	1	53	47	4	44	102726	15	86 7	37	1 5	4 9	0	39	7
2 4	1	58	29	4	42	102711	15	90 4	37	1 6	2 3	0	39	6
2 5	2	3	8	4	39	102695	16	94 1	37	1 7	7	0	39	5
2 6	2	7	44	4	36	102678	17	97 8	37	1 7	4 5	0	38	4
2 7	2	12	18	4	34	102660	18	10 15	37	1 8	2 3	0	38	3
2 8	2	16	50	4	32	102642	18	10 52	37	1 9	1	0	38	2

A	Ep	Ep	Ep	Di	Di		Dif(	Ecc	Dif	V	V			Ar
r	ic	ic	ic	ff1	ff1	Elong	sub	ent	(A	a	a	Diff(A	Diff(A	g
g	G	M	S	M	S	à Cen	)	r	d)	M	S	dd) M	dd) S	↓
2	2	21	20	4	30	102623	19	10	37	1	3	0	37	1
9								89		9	8			
3	2	25	47	4	27	102604	19	11	36	2	1	0	37	0
0								25		0	5			

Footer rubrics (printed beneath the columns): Add [Adde] | Subtract [Subtr.] | (Elongation) | Ad[d] | Sub[tract] | Subtract [Subt.] | Subtract [Subt.] — these give the sign of each correction when the argument is taken from the foot upward.

Row count: 31 main argument rows (0–30), with the interleaved half-row difference entries transcribed where they print. Bottom of grid reached. Strips sufficient.

Table of Lunar Prosthaphaereses — 1 Sign

Table of Lunar Prosthaphaereses [Tabula Prosthaphaeresium Lunarium] — 1 Sign [1. Signum]

Same column structure as the 0-Signs table, for the argument 1 sign (30°–60°). The argument index again runs 0–30 down the left edge (representing the degrees within this sign). The header rubrics: Prosthaphaeresis of the epicycle [Prosth. Epic.] — Subtract [Subtr.]; Difference [Diff.] — Add [Add.]; Elongation from Centre [Elô. à Cē.]; Difference [Dif.] — Subtract [Sub]; Eccentric [Eccentrici] — (Subtract); Difference [Dif.] — Add [Ad.]; Variation [Variatio] — Add [Adde]; Difference [Diff.] — Add [Adde], with descending edge argument 30 → 0.

A	Ep	Ep	Ep	Di	Di		Dif(	Ecc	Dif	V	V			Ar
r	ic	ic	ic	ff1	ff1	Elong	sub	ent	(A	a	a	Diff(A	Diff(A	g
g	G	M	S	M	S	à Cen	)	r	d)	M	S	dd) M	dd) S	↓
0	2	25	47			102604		11		2	1	0	36	30
								25		0	5			
1	2	30	12	4	25	102584	20	11	37	2	5	0	36	29
								62		0	1			
2	2	34	34	4	22	102563	21	11	36	2	2	0	36	28

A r g	Ep ic G	Ep ic M	Ep ic S	Di ff1 M	Di ff1 S	Elong à Cen	Dif (sub)	Ecc ent r	Dif (A d)	V a r M	V a r S	Diff(A dd) M	Diff(A dd) S	Ar g ↓
								98		1	7			
				4	20		21		37			0	36	
3	2	38	54	4	17	102542	21	12	37	2	3	0	35	27
								35		2				
4	2	43	11	4	14	102520	22	12	36	2	3	0	35	26
								71		2	8			
5	2	47	25	4	12	102497	23	13	36	2	1	0	35	25
								07		3	3			
6	2	51	37	4	9	102474	23	13	37	2	4	0	35	24
								44		3	8			
7	2	55	46	4	6	102450	24	13	36	2	2	0	34	23
								80		4	2			
8	2	59	52	4	2	102426	24	14	36	2	5	0	34	22
								16		4	6			
9	3	3	54			102401	25	14	35	2	2	0	33	21
								51		5	9			
1	3	7	53	3	59	102375	26	14	36	2	2	0	33	20
0								87		6				
1	3	11	49	3	56	102348	27	15	36	2	3	0	32	19
1								23		6	4			
1	3	15	42	3	53	102321	27	15	35	2	6	0	32	18
2								58		7				
1	3	19	31	3	49	102293	28	15	36	2	3	0	32	17
3								94		7	9			
1	3	23	17	3	46	102265	28	16	35	2	8	0	31	16
4								29		8				
1	3	26	59	3	42	102236	29	16	35	2	3	0	30	15
5								64		8	8			
1	3	30	38	3	39	102206	30	16	35	2	8	0	30	14
6								99		9				
1	3	34	13	3	35	102176	30	17	35	2	3	0	29	13

A r g	Ep ic G	Ep ic M	Ep ic S	Di ff1 M	Di ff1 S	Elong à Cen	Dif (sub)	Ecc ent r	Dif (A d)	V a r M	V a r S	Diff(A dd) M	Diff(A dd) S	Ar g ↓
7								34		9	7			
1 8	3	37	44	3	31	102145	31	17 69	35	3	6	0	29	12
1 9	3	41	12	3	28	102114	31	18 04	35	3	3	0	28	11
2 0	3	44	36	3	24	102082	32	18 38	34	3	1	0	27	10
2 1	3	47	56	3	20	102049	33	18 72	34	3	2	0	27	9
2 2	3	51	12	3	16	102016	33	19 06	34	3	5	0	27	8
2 3	3	54	24	3	12	101982	34	19 40	34	3	2	0	26	7
2 4	3	57	32	3	8	101948	34	19 74	34	3	4	0	25	6
2 5	4	0	36	3	4	101913	35	20 08	34	3	1	0	25	5
2 6	4	3	35	2	59	101877	36	20 42	34	3	3	0	24	4
2 7	4	6	30	2	55	101841	36	20 75	33	3	5	0	23	3
2 8	4	9	21	2	51	101804	37	21 08	33	3	2	0	23	2
2 9	4	12	8	2	47	101767	37	21 41	33	3	4	0	23	1
3 0	4	14	51	2	43	101729	38	21 74	33	3	4	0	21	0

Footer rubrics (printed beneath the columns): Add [Adde] | Subtract [Subt.] |
(Elongation) | Ad[d] | Sub[tract] | Subtract [Subt.] | Subtract [Subt.].

Row count: 31 main argument rows (0–30). Bottom of grid reached. Strips
sufficient.

Table of Lunar Prosthaphaereses (continued)

The sexagesimal sub-units (minutes, seconds) are transcribed verbatim. Each grid runs from argument 0 through 30 (31 rows). The interstitial **Diff.** columns hold the first differences, printed between the two rows they bridge; they are transcribed against the lower of the two bracketed rows as printed.

2 SIGNA (head) / 9 SIGNA (foot)

[Head rubric: **TABVLA PROSTHAPHÆRESIVM LVNARIVM. — 2. SIGNA.**]

Column headers as printed: **Prosth. Epic.** (Subtr. — G M S) · **Diff.** (Add: — M S) · **Elong. a Centro** · **Dif.** (Sub.) · **Eccentrici** · **Dif.** (Ad) · **Variatio** (Adde — M S) · **Diff.** (Adde — M S) · [complement argument]

A	Pr.Ep.	Diff.			Elon	Di	Eccentr	Di	Var.	Diff.			Co	
r	G	M	S	M	S	g.	f.	.	f.	M	S	M	S	mp.
0	4	1	5			1017		2174		35	4			30
		4	1			29								
1	4	1	2	2	3	1016	38	2207	33	35	2	0	2	29
		7	9		8	91					5		1	
2	4	2	2	2	3	1016	39	2240	33	35	4	0	2	28
		0			3	52					5		0	
3	4	2	3	2	2	1016	39	2272	32	36	5	0	2	27
		2	1		9	13							0	
4	4	2	5	2	2	1015	40	2304	32	36	2	0	1	26
		4	5		4	73					4		9	
5	4	2	1	2	1	1015	41	2336	32	36	4	0	1	25
		7	4		9	32					2		8	
6	4	2	2	2	1	1014	41	2368	32	37	0	0	1	24
		9	9		5	91							8	
7	4	3	3	2	1	1014	42	2400	32	37	1	0	1	23
		1	9		0	49					7		7	
8	4	3	4	2	5	1014	42	2432	32	37	3	0	1	22
		3	4			07					3		6	
9	4	3	4	2	0	1013	42	2463	31	37	4	0	1	21
		5	4			65					8		5	

A	Pr.Ep.	Diff.			Elon	Di	Eccentr	Di	Var.	Diff.		Co
g	G	M	S	M	S g.	f.	.	f.	M	S	M	S mp.
1	4	3	3	1	5 1013	43	2494	31	38	3	0	1 20
0		7	9		5 22							5
1	4	3	3	1	5 1012	43	2525	31	38	1	0	1 19
1		9	0		1 79					7		4
1	4	4	1	1	4 1012	44	2556	31	38	3	0	1 18
2		1	7		7 35					0		3
1	4	4	5	1	4 1011	44	2587	31	38	4	0	1 17
3		2	9		2 91					2		3
1	4	4	3	1	3 1011	45	2617	30	38	5	0	1 16
4		4	5		6 46					5		2
1	4	4	5	1	3 1011	45	2647	30	39	7	0	1 15
5		6			0 01							2
1	4	4	3	1	2 1010	46	2677	30	39	1	0	1 14
6		7	0		5 55					8		1
1	4	4	5	1	2 1010	46	2707	30	39	2	0	1 13
7		8	0		0 09					8		0
1	4	5	6	1	1 1009	46	2737	30	39	3	0	9 12
8		0			6 63					7		
1	4	5	1	1	1 1009	47	2766	29	39	4	0	8 11
9		1	6		0 16					5		
2	4	5	2	1	5 1008	47	2795	29	39	5	0	8 10
0		2	1		69					3		
2	4	5	2	1	0 1008	48	2824	29	40	0	0	7 9
1		3	1		21							
2	4	5	1	0	5 1007	48	2853	29	40	6	0	6 8
2		4	6		5 73							
2	4	5	5	0	4 1007	48	2881	28	40	1	0	6 7
3		5			9 25					2		
2	4	5	4	0	4 1006	49	2909	28	40	1	0	5 6
4		5	9		4 76					7		
2	4	5	2	0	3 1006	49	2937	28	40	2	0	4 5
5		6	8		9 27					1		

A r g	Pr.Ep. G	Diff. M S M			Elon S g.	Di f.	Eccentr .	Di f.	Var. M	Diff. S M		Co S mp.	
2 6	4	5 7	1	0	3 3	1005 78	49	2965	28	40	2 5	0	4 4
2 7	4	5 7	2	0	2 8	1005 28	50	2993	28	40	2 7	0	2 3
2 8	4	5 7	5	0	2 2	1004 78	50	3021	28	40	2 8	0	1 2
2 9	4	5 8	8	0	1 7	1004 28	50	3048	27	40	2 9	0	1 1
3 0	4	5 8	2	0	1 2	1003 78	50	3075	27	40	3 0	0	0

[Foot rubric (for the complement **9 SIGNA**, read upward): (**Adde** | **Subt.** | | **Ad.** | | **Sub.** | **Subt.** | | **Subt.** (] [Foot continuation heading: **9. SIGNA.**]

3 SIGNA (head) / 8 SIGNA (foot)

[Head rubric: **TABVLA PROSTHAPHÆRESIVM LVNARIVM. — 3 SIGNA.**]

Column headers as printed: **Prosth. Epici.** (Subtrahe — G M S) · **Diffra** (Adde — M S) · **Elong. a Cen.** · **Dif.** (Sub.) · **Eccentrici** · **Dif.** (Ad.) · **Variatio** (Adde — M S) · **Diffra** (Adde — M S) · [complement argument]

A r g	Pr.E p. G	S	Diff . M		Elong.	D if .	Ecce ntr.	D if .	Va r. M	Diff . M	C o m p.
0	4	20			100378		3075		40		30
1	4	26	0		100327	5 1	3102	2 7	40	0	29
2	4	27	0		100276	5 1	3128	2 6	40	0	28
3	4	22	0		100225	5 1	3154	2 6	40	0	27
4	4	14	0		100174	5 1	3180	2 6	40	0	26

A	Pr.E		Diff		D	D	Va		C
r	p. G	S	. M	Elong.	if	Ecce	if	r. M	o
g					.	ntr.	.		m
									p.
5	4	59	0	100123	5	3206	2	40	25
					1		6		
6	4	37	0	100072	5	3231	2	40	24
					1		5		
7	4	10	0	100021	5	3256	2	40	23
					1		5		
8	4	38	0	99969	5	3281	2	40	22
					2		5		
9	4	1	0	99917	5	3306	2	40	21
					2		5		
1	4	81 [recte: 18?]	0	99865	5	3331	2	39	20
0					2		5		
1	4	30	0	99813	5	3355	2	39	19
1					2		4		
1	4	36	0	99761	5	3379	2	39	18
2					2		4		
1	4	37	0	99709	5	3403	2	39	17
3					2		4		
1	4	33	1	99657	5	3426	2	39	16
4					2		3		
1	4	23	1	99605	5	3449	2	39	15
5					2		3		
1	4	7	1	99553	5	3472	2	38	14
6					2		3		
1	4	46	1	99501	5	3495	2	38	13
7					2		3		
1	4	21	1	99449	5	3518	2	38	12
8					2		2		
1	4	50	1	99397	5	3540	2	38	11
9					2		2		

A r g	Pr.E p. G	S	Diff . M	Elong.	D if .	Ecce ntr.	D if .	Va r. M	Diff . M	C o m p.
2 0	4	13	1	99343	5 2	3562	2 2	38	0	10
2 1	4	31	1	99293	5 1	3584	2 1	37	0	9
2 2	4	43	1	99242	5 1	3605	2 1	37	0	8
2 3	4	51	1	99191	5 1	3626	2 1	37	0	7
2 4	4	54	1	99140	5 1	3647	2 0	37	0	6
2 5	4	51	2	99089	5 1	3667	2 0	36	0	5
2 6	4	42	2	99038	5 1	3687	2 0	36	0	4
2 7	4	29	2	98987	5 1	3707	2 0	36	0	3
2 8	4	11	2	98937	5 0	3727	2 0	35	0	2
2 9	4	48	2	98887	5 0	3746	1 9	35	0	1
3 0	4	20	2	98883 [recte: 98837?]	4 9	3765	1 9	35	0	0

[Foot rubric (for the complement **8 SIGNA**, read upward): **Adde** | **Ad.** | | **Ad.** | | **Sub.** | **Subt.** | | **Ad.**] [Foot continuation heading: **8 SIGNA.**]

4 SIGNA (head) / 7 SIGNA (foot)

[Head rubric: **TABVLA PROSTHAPHÆRESIVM LVNARIVM. — 4. SIGNA.**]

Column headers as printed: **Prosth. Epic.** (Subtr. — G M S) · **Diff.** (Subt: — M S) · **Elong. a Centro** · **Dif.** (Sub.) · **Eccentrici** · **Dif.** (Ad) · **Variatio** (Adde — M S) · **Diff.** (Subt. — M S) · [complement argument]

A	Pr.Ep.	Diff.		D	Eccen	D	Var	Diff.	Co
g	G	MS M	S Elong.	if.	tr.	if.	. M	S M	m S p.
0	4	2 2 2 0	98838		3765		35	4	30
1	4	1 4 2 9 6	3 98789 4	4 9	3784	1 9	34	4 0 3	2 29 1
2	4	1 7 2 7	3 98740 9	4 9	3803	1 9	34	2 0 1	2 28 2
3	4	1 2 2 4 4	4 98691 3	4 9	3821	1 8	33	5 0 8	2 27 3
4	4	1 3 2 1 6	4 98643 8	4 8	3839	1 8	33	3 0 5	2 26 3
5	4	8 4 2 3	5 98595 3	4 8	3857	1 8	33	1 0 1	2 25 4
6	4	5 4 2 5	5 98547 8	4 8	3874	1 7	32	4 0 6	2 24 5
7	4	2 4 3 2	3 98500	4 7	3891	1 7	32	2 0 1	2 23 5
8	3	5 3 3 9 5	7 98453	4 7	3908	1 7	31	5 0 5	2 22 6
9	3	5 2 3 6 3	1 98407 2	4 6	3924	1 6	31	2 0 8	2 21 7
10	3	5 6 3 3	1 98361 7	4 6	3940	1 6	31	1 0	2 20 7
11	3	4 4 3 9 5	2 98316 1	4 5	3956	1 6	30	3 0 4	2 19 7
12	3	4 2 3 6 0	2 98272 5	4 4	3972	1 6	30	6 0	2 18 8
13	3	4 5 3 2 0	3 98228 0	4 4	3987	1 5	29	3 0 7	2 17 9
14	3	3 1 3 9 6	3 98185 4	4 3	4002	1 5	29	8 0	2 16 9
15	3	3 3 3 5 8	3 98142 8	4 3	4017	1 5	28	3 0 8	3 15 0

A	Pr.Ep.	Diff.		D	Eccen	D	Var	Diff.	Co
g	G	MS M	S Elong.	if.	tr.	if.	. M	S M	m
1	3	3 5 3	4 98100	4	4031	1	28	8 0	3 14
6		1 5	3	2		4			0
1	3	2 8 3	4 98059	4	4045	1	27	3 0	3 13
7		8	7	1		4		7	1
1	3	2 1 3	5 98018	4	4059	1	27	6 0	3 12
8		4 8	0	1		4			1
1	3	2 2 3	5 97978	4	4073	1	26	3 0	3 11
9		0 4	4	0		4		4	2
2	3	1 2 3	5 97398 [recte:	4	4086	1	26	2 0	3 10
0		6 5	8 97938?]	0		3			2
2	3	1 2 4	3 97899	3	4099	1	25	2 0	3 9
1		2 2		9		3		9	3
2	3	8 1 4	7 97861	3	4111	1	24	5 0	3 8
2		5		8		2		6	3
2	3	4 5 4	1 97824	3	4123	1	24	2 0	3 7
3			0	7		2		2	4
2	2	5 5 4	1 97787	3	4135	1	23	4 0	3 6
4		9 2	3	7		2		8	4
2	2	5 3 4	1 97751	3	4147	1	23	1 0	3 5
5		5 5	7	6		2		3	5
2	2	5 1 4	2 97716	3	4158	1	22	3 0	3 4
6		1 4	1	5		1		8	5
2	2	4 4 4	2 97682	3	4169	1	22	3 0	3 3
7		6 9	5	4		1			5
2	2	4 2 4	2 97649	3	4180	1	21	2 0	3 2
8		2 1	8	3		1		7	6
2	2	3 5 4	3 97616	3	4190	1	20	5 0	3 1
9		7 1	0	3		0		1	6
3	2	3 1 4	3 97584	3	4200	1	20	1 0	0
0		3 8	3	2		0		5	

[Foot rubric (for the complement **7 SIGNA**, read upward): **Adde** | **Subt.** | | **Ad.** | | **Sub.** | **Subt.** | | **Adde**] [Foot continuation heading: **7 SIGNA.**]

5 SIGNA (head) / 6 SIGNA (foot)

[Head rubric: **TABVLA PROSTHAPHÆRESIVM LVNARIVM. — 5 SIGNA.**]

Column headers as printed: **Prosth. Epici.** (Subtrahe — G M S) · **Diffra** (Adde — M S) · **Elong. a Cen.** · **Dif.** (Sub.) · **Eccentrici** · **Dif.** (Ad.) · **Variatio** (Adde — M S) · **Diffra** (Adde — M S) · [complement argument]

A	Pr.Ep.	Diff.		Elon	Di	Eccentr	Di	Var.	Diff.		Co
g	G	M	S M	S g.	f.	.	f.	M	S	M	S mp.
0	2	3	1	9758		4200		20	1		30
		3	8	4					5		
1	2	2	4 4	3 9755	31	4210	10	19	3	0	3 29
		8	1	7 3					8		7
2	2	2	1 4	4 9752	30	4219	9	19	1	0	3 28
		4		0 3							7
3	2	1	1 4	4 9749	29	4228	9	18	2	0	3 27
		9	8	3 4					3		8
4	2	1	3 4	4 9746	28	4236	9	17	4	0	3 26
		4	3	5 6					5		8
5	2	9	4 4	4 9743	27	4245	8	17	7	0	3 25
		5		8 9							8
6	2	4	5 4	5 9741	26	4253	8	16	2	0	3 24
		5		0 3					3		9
7	2	0	2 4	5 9738	25	4261	8	15	4	0	3 23
				3 8					9		9
8	1	5	7 4	5 9736	24	4268	7	15	1	0	3 22
		5		5 4					0		9
9	1	5	9 4	5 9734	23	4275	7	14	3	0	3 21
		0		8 1					1		9
1	1	4	8 5	1 9732	21	4282	7	13	5	0	4 20
0		5		0					1		0
1	1	4	5 5	3 9729	21	4288	6	13	1	0	4 19
1		0		9					1		0
1	1	3	1 5	4 9727	20	4294	6	12	3	0	4 18
2		5		9					1		0

A	Pr.Ep.	Diff.		Elon	Di	Eccentr	Di	Var.	Diff.		Co
g	G	M	S M	S g.	f.	.	f.	M	S	M	S mp.
1	1	2	5 5	6	9726	19	4300	6	11	5 0	4 17
3		9	5	0					1		0
1	1	2	4 5	8	9724	18	4306	6	11	1 0	4 16
4		4	7	2					0		1
1	1	1	3 5	9	9722	17	4311	5	10	2 0	4 15
5		9	8	5					9		1
1	1	1	2 5	1	9720	16	4316	5	9	4 0	4 14
6		4	7	1	9				3		1
1	1	9	1 5	1	9719	15	4320	4	9	7 0	4 13
7			4	3	4						1
1	1	3	5 5	1	9718	14	4324	4	8	2 0	4 12
8			9	5	0				6		2
1	0	5	4 5	1	9716	13	4328	4	7	4 0	4 11
9		8	3	6	7				4		2
2	0	5	2 5	1	9715	12	4332	3	7	2 0	4 10
0		3	7	6	5						2
2	0	4	1 5	1	9714	11	4335	3	6	2 0	4 9
1		8	0	7	4				0		2
2	0	4	5 5	1	9713	10	4338	3	5	3 0	4 8
2		2	2	8	4				8		2
2	0	3	3 5	1	9712	8	4340	2	4	5 0	4 7
3		7	3	9	6				6		2
2	0	3	1 5	2	9712	6	4342	2	4	1 0	4 6
4		2	3	0	0				4		2
2	0	2	5 5	2	9711	5	4344	2	3	3 0	4 5
5		6	2	1	5				2		2
2	0	2	3 5	2	9711	4	4345	1	2	5 0	4 4
6		1	0	2	1				0		2
2	0	1	8 5	2	9710	3	4346	1	2	8 0	4 3
7		6		2	8						2
2	0	1	4 5	2	9710	3	4347	1	1	2 0	4 2
8		0	6	2	5				6		3

A												
r	Pr.Ep.		Diff.		Elon	Di	Eccentr	Di	Var.		Diff.	Co
g	G		M S M		S g.	f.	.	f.	M		S M	S mp.
2	0		5 2 5		2 9710	3	4348	0	0		4 0	4 1
9			3		3 2						3	3
3	0		0 0 5		2 9710	2	4348	0	0		0 0	0
0					3 0							

[Foot rubric (for the complement **6 SIGNA**, read upward): **Adde** | **Ad.** | | **Ad.** | | **Sub.** | **Subt.** | | **Ad.**] [Foot continuation heading: **6 SIGNA.**]

On the Computation of the True Longitude of the Moon from These Tables

[DE VERÆ LONGITVDINIS LVNAE EX hisce tabulis supputatione.]

First of all, for a given time — reckoned by the old Julian Calendar, which we have always used throughout these *Progymnasmata*, and adjusted according to our own method, using for the Sun the table of the equation [of time] that is appended to the earlier treatise on the Sun's course — and for the Moon the [table] we have just set out: investigate first the mean longitude of the Sun, then its true longitude. From the tables of the Moon's mean motion, in the way customary elsewhere, derive the [mean motions] corresponding to the same equated time, and add the mean motion of the Moon to the mean [motion] of the Sun, so that the Moon's longitude from the vernal equinox is established.

Second, with the Moon's anomaly enter the table of prosthaphaereses, and extract the epicyclic prosthaphaeresis [prosthaphaeresin epicyclicam] together with the elongation from the center [elongatione à centro] — applying the correction by the proportional part if the degrees of anomaly carry [odd] minutes [scrupula]. Then add that [prosthaphaeresis] both to the Moon's longitude from the equinox and to the anomaly, as the requirement of the column headings demands, or subtract it from them, so that both come out equated.

Third, subtract the true place of the Sun from the equated longitude of the Moon, and with the doubled remainder look up in the table of equations the eccentricity [eccentricitatem] together with the variation [variatione] — not neglecting, however, the proportional part due, should there be need — which [variation] is set aside separately.

Fourth, if that doubled distance of the luminaries [duplex distantia luminarium], with which you entered the table, is less than a semicircle, its complement is halved up to the semicircle. Or, if it is greater than a semicircle, the excess above the semicircle is likewise halved, and there is produced the angle of the second equation of anomaly [angulus secundæ æquationis anomalïæ]; this is added to the equated anomaly before the semicircle of the doubled distance of the luminaries, but after [the semicircle] it is subtracted from it, so that the second-equated anomaly results. And if this is less than a semicircle, let it be bisected; or if greater, let its complement up to the whole circle be bisected; and the tangent of this bisected angle, taken from the table of tangents, will be the third quantity found [Inventum tertium].

Fifth, add the elongation from the center and the eccentricity to each other, halve the product, and you will have the first quantity found [Inventum primum]; subtract the eccentricity from this, and it leaves the second quantity found [Inventum secundum], which you multiply by the tangent of the bisected arc, that is, the third quantity found; divide the resulting number by the first quantity found; the quotient will be a tangent, whose corresponding angle, subtracted from the bisected angle already mentioned, leaves the prosthaphæresis of the eccentricity [Eccentricitatis Prosthaphæresin], to be subtracted from the second-equated anomaly before the semicircle, but to be added to it after the semicircle.

This, however, must be carefully noted: if the angle of the second equation is subtractive [ablativus], and is greater than the anomaly itself, the anomaly is to be subtracted from it, and with the remaining bi-

-sected tangent, as before, one must proceed: and the angle of the prosthaphæresis of the eccentricity will be additive [adjectivus].

This prosthaphæresis and the variation [Variationem], which you had set aside, add to the equated longitude of the Moon from the equinox according to the character of each, or subtract it from that [longitude], and you will obtain the true place of the Moon from the equinox.

EXAMPLE

[EXEMPLVM.]

In the year of Christ 1587, on the 18th day of August at 17 hours 2[?7] minutes after midday [a m. = a meridie], the true place of the Moon was observed by our instruments at 26 P. 23 / Gemini [♊]. Now since the Sun was at that time in 4 [P. of] Virgo [♍], I enter the table of the equation of natural days, the earlier one,

with this degree, and in the common angle there appears an equation of 7 /, to be subtracted from the apparent time so that it comes out equal: 16 D. 19 H. 18 / [16 days, 19 hours, 18 minutes]. For this time, accordingly, the mean motions are gathered. The apogee of the Sun will be 3 S. 5 P. 29 / 43 //; the Sun's simple [mean longitude] 5 S. 5 P. 50 / 21 //; the prosthaphaeresis of the Sun 1 P. 45 / 9 // subtractive [S.]. Hence the true place of the Sun [is] 4 P. 5 / 12 // Virgo [♍].

Now, with the place [of the Sun] found, having entered the later table of the equation of time, I find 7 / 36 // to be added to the apparent time, so that it becomes equated. For this likewise the mean motions are gathered, and they will be: the longitude of the Moon from the Sun 9 S. 25 P. 13 / 13 //; the anomaly of the Moon 1 S. 15 P. 37 / 29 //; the motion of latitude [Motus Latitudinis] 9 S. 0 P. 57 / 20 //.

Next, with the anomaly of the Moon I extract from the table of prosthaphaereses the epicyclic prosthaphaeresis, applying the correction through the proportional part, [as] 3 P. 29 / 16 // subtractive [S.], and the elongation from the center [as] 1 0 2 2 17 [i.e. 102217 in the units of the table], which I reserve for a while. The Sun's simple [longitude] I add to the longitude of the Moon from the Sun, and I produce the simple longitude of the Moon from the vernal equinox, 3 S. 1 P. 3 / 34 //. From this is subtracted the epicyclic prosthaphaeresis 3 P. 29 / 16 //, and the equated longitude remains 2 S. 27 P. 34 / 18 //. The same prosthaphaeresis is taken from the anomaly, so that this too comes out equated as 1 S. 12 P. 8 / 13 //. Then from the equated longitude of the Moon is subtracted the true place of the Sun, and there remains the distance of the luminaries close to 9 S. 23 P. 29 / 6 //. This doubled gives 7 S. 16 P. 58 / 12 //.

With this, in turn, from the tables of lunar equations I draw out the eccentricity, 3 9 8 7 part[s], and the variation of the center of the epicycle [variationem Centri Epicicli] 29 / 36 //, subtractive [Subt.]. But since the doubled distance of the luminaries is greater than a semicircle, the excess above the semicircle is divided in two, and there comes out 23 P. 29 / 6 //, the angle of the second equation, to be subtracted from the anomaly. The epicyclic prosthaphaeresis, however, having been subtracted from the mean anomaly, leaves it first-equated as 1 S. 12 P. 8 / 13 //. From this, when the angle of the second equation just found is again subtracted, it leaves the anomaly second-equated as 18 P. 39 / 7 //. And since this is less than a semicircle, it is immediately bisected, and there comes out 9 P. 19 / 34 //. The tangent of this, 1 6 4 2 2 4 2 [i.e. 1642242], is the third quantity found [Inventum tertium].

Afterward I add to each other the elongation from the center, which I had earlier reserved, and the eccentricity, and the half of the sum, 5 3 1 0 2 [i.e. 53102], becomes the first quantity found [Inventum primum]: from this I subtract the eccentricity, and there remains 9 4 1 1 5 [i.e. 94115], the second quantity found, which I multiply by the tangent,

namely the third quantity found, and there arises 8 0 6 5 8 7 1 5 8 3 0 [i.e. 80658715830]. This, divided by the first quantity found, yields the fourth proportional, 1 5 1 8 9 3 9 [i.e. 1518939], a tangent whose arc is 8 P. 38 / 12 //; subtracted from the arc of the prior tangent, 9 P. 19 / 34 //, it leaves the prosthaphaeresis of the eccentricity [Protha: Eccentricitatis] 41 / 22 // to be subtracted, because the anomaly of the Moon, when second-equated, was less than a semicircle. This [prosthaphaeresis], together with the variation of the center of the epicycle, having been subtracted from the equated motion of the longitude of the Moon from the equinox, leaves the true place of the Moon at 26 P. 23 / 20 // Gemini [II], with respect to its proper orbit.

But, so that it may be reduced to the ecliptic — about which more will be said later — let 1 / 9 // be subtracted, and the true place of the Moon comes out as 26 P. 22 / 9 // Gemini [II] with respect to the poles of the ecliptic. The Alphonsine reckoning [Alphonsinus Calculus] gives 27 P. 43 / Gemini [II], discrepant from the heavens [by] 1 P. 10 /; the Copernican [reckoning] gives 27 P. Gemini [II] plus 36 /.

On the Longitude of the Moon, to Be Demonstrated Geometrically from Our Hypothesis by Triangles

[DE LONGITVDINE LVNÆ E NOSTRA HYPOTHESI PER TRIANGVLA GEOMETICE DEMONSTRANDA]

Diagram. A large circle (the deferent or eccentric, centered near point B with the Earth's globe drawn at C in the lower-center small circle) dominates the page. At the upper left is a smaller circle-cluster representing the doubled epicyclic apparatus (epicycle-on-epicycle), and the principal radial lines run from the lower epicycle's center across to the upper epicycle. A separate small detached circle at the lower left appears to be an auxiliary/key diagram for the small epicycle. The dashed line E runs diagonally as a sight-line. Letters read from the figure (positions approximate; several small peripheral labels are uncertain on this scan):

- D (top): point at the top of the large circle, on the vertical diameter D–K
- K (bottom): point at the bottom of the large circle, on the vertical diameter

- E: label near the top, at the upper end of the dashed sight-line
- Upper-left circle-cluster: M (top), T [or τ] (upper), G (left), N (interior), Y [or Y] (interior, near a small Sun/Earth glyph), O (interior)
- Lower-center small circle (around the Earth's globe at C): I[?] (top, by C), X (interior), B (center), L (right), V (lower left), A (bottom, on the vertical diameter)
- Detached small circle, lower left (auxiliary/key figure): 7 [or "2"] (top), F (left), S (center), Z (right), [?] (bottom), with a small glyph at lower left

It is desirable, moreover, to investigate from our hypothesis — indicated earlier — the longitude of the Moon by the reasoning of triangles, without the tables of prosthaphaereses, so that their agreement may be evident. So, taking up the earlier observation, made (as I said) in the year 1587, on the 18th day of August, at 7 hours 25 minutes, the mean motions have already become known above from the tables. Let it be, then, that in the appended diagram [Delineatione] the mean anomaly of the Moon is DEF 1 S. 15 P. 37 / 29 //. Since that [anomaly], which in the first epicycle [is reckoned] from the apogee — as was said earlier in the explanation of the hypothesis — is equal to GH, [extending] up to the center of the second epicycle H: let the same anomaly doubled, 3 S. 14 P. 1 / 56 //, be counted from N in the second epicycle through P, up to the point T of the Moon, and let the line TF be drawn. Now in the oblique-angled triangle THF the two sides TH, the semidiameter of the second epicycle, 2900, and HF, the semidiameter of the first epicycle, 5800, are given, together with the angle THF contained by them, which is the doubled anomaly itself. There result, therefore, by the demonstrated [doctrine] of triangles, the angle FHF [recte: TFH] 26 P. 18 / 43 //, and the side TF 6541.

Then in the other triangle TFC, the side TF is given as just found, 6541, and the side FC, the radius of the eccentric, 100000, together with the contained angle TFC, which is 108 P. 3 / 49 //. This is, of course, the complement of the angle HFT of the simple anomaly [HF τ ?] just noted. There becomes known, therefore, by calculation the angle TCF, the epicyclic prosthaphaeresis, 3 P. 29 / 16 //, together with the side CT of the elongation [latere Elongationis] 102217. The mean [longitude] of the Moon from the Sun is added to the [Sun's] longitude, so that the simple longitude of the Moon from the equinox is obtained, 3 S. 1 P. 3 / 34 //. From this is subtracted the epicyclic prosthaphaeresis 3 P. 29 / 16 //, and the equated longitude remains 2 S. 27 P. 34 / 18 //. The same prosthaphaeresis is taken from the anomaly, so that this too may come out equated as 1 S. 12 P. 8 / 13 //.

Next, from the equated longitude of the Moon the true place of the Sun is subtracted, and there remains the distance of the luminaries 9 S. 23 P. 29 / 6 //. Its double, 7 S. 16 P. 58 / 12 //, [marks] in the small circle near the Earth the point[s] A, L, I, C, up to the center of the eccentric C. Let CB and CA be joined, and let the isosceles triangle CBA be constituted, whose exterior angle CB[A] is known, namely the excess of the doubled distance of the luminaries above the semicircle, 46 P. 58 / 12 //. Half of this is BAC 23 P. 29 / 6 //; by [Euclid] 20, [book] I, [recte: Elements I.32] the angle of the second equation of anomaly, to which ECD by [Euclid] I.28 is equal, [is] to be subtracted

from the previously equated anomaly TCD, and there remains the anomaly second-equated TCE 18 P. 39 / 7 //. This, subtracted from the semicircle, leaves the interior [angle] TCA 161 P. 20 / 53 //.

The side CA of the eccentricity, however, is investigated in this way. The arc CA in the small circle near the Earth is 133 P. 1 / 48 //. [This is] the complement, namely, of the true distance of the luminaries up to the whole circle. Its subtense [chord] is CA; the half of the arc CA is CV 66 P. 30 / 54 //; its sine [sinus rectus] CX [is] 917 1634 [i.e. 9171634, in units of radius = 10000000]. Therefore, as the radius is to this sine, so is CB, the semidiameter of the small circle, 2174, to CX, 1994; the double of this, 3988, is CA, the eccentricity in the same

in the same parts of which BA is 2174. In this triangle TCA, therefore, two sides are given — TC, the elongation of the Moon from the center, and CA, the eccentricity just now found — together with the angle TCA contained by them. The angle ATC, then, will be given as 41' 22": the prosthaphaeresis of the eccentricity, and TA the distance of the Moon from the Earth in parts of which the semidiameter of the eccentric is CF. This prosthaphaeresis is subtracted from the equated longitude of the Moon, and the place of the Moon will be produced at 2 S. 26° 52' 56". There remains, in the last place, the libration of the center of the epicycle to be unravelled.

The motion of the said libration is commensurate with the double distance of the luminaries, and it begins; it is understood to be moved in its apogee, and in the opposite direction — namely in the order of the succession of the signs — with respect to the first epicycle, when the double longitude of the Moon from the Sun is 7 S. 16° 58' 12". The sine of the excess beyond the semicircle from O is 7309965, namely the line BO or FS. Therefore, as the whole sine SP is to SF, so is the greatest variation of the libration of the center of the epicycle, 40' 30", to FS; this gives the variation of the said distance of the true luminaries, 29' 36", suited to it. This is to be subtracted from the last equated longitude of the Moon, so that the

true place of the Moon comes out at $26^{\circ} 23' 20''$ Gemini — and indeed in its own course.

But in order that it may be reduced to the Ecliptic, the true motion of latitude is $8^{\circ} 25' 4' 9''$ (of which more is to be said shortly); the little table assigned for this purpose gives $1' 9''$, so that the true place with respect to the Ecliptic is $26^{\circ} 22' 9''$ Gemini, which agrees entirely with the place we found above by means of the tables.

DE LATITUDINE LUNAE.

Astronomers have long since established that the Moon does not complete its course beneath the Ecliptic, the Sun's path — so much so that a divergence from it has been found to swell to as much as five degrees, very nearly, on either side. The nodes, however, or intersections with the Ecliptic, do not remain in the same places, but anticipate themselves backward, so that they complete their period in 3 days, 11 [hours]; and within nearly nineteen years. Yet up to now all practitioners have held it as certain that the limits of the Moon's greatest latitude remain perpetually equal to themselves, and reach precisely five degrees — chiefly on the authority of Ptolemy [Ptolemaeus], whom al-Battānī [Albategnius] followed, and after him Alphonsus [Alfonso]; and in this even Copernicus too acquiesced, somewhat too uncritically, as he often did elsewhere.

Moreover, it has hitherto been believed in vain that the nodes themselves maintain an equal and regular motion. For in neither of these matters do our observations — made over several past years with the greatest diligence — agree with the traditions of the ancients, long received though they be. For not only have we discovered limits of the greatest latitude other than what Ptolemy laid down, but also ones that differ among themselves: at the new and full moons indeed corresponding very nearly to the Ptolemaic statement. For at those times the Moon, departing from the Ecliptic,

we have ascertained, can depart $4^{\circ} 58' 30''$. But at the quadratures it increases this divergence by nearly a third part, so that it then amounts to $5^{\circ} 17' 30''$, just as diligent and often-repeated examination concerning both has taught us; the limit, whether northern or southern, and at both tropical places, having been handled with care: so that not only the parallaxes everywhere, but also the reckoning of refraction, has been brought to bear in the lower situation.

But if Ptolemy, around the quadratures — as is most likely — examined the Moon's greatest latitude when it was situated near the summer tropic [Cancer],

close to the vertex, he ought certainly to have found that same latitude smaller by 20' than it now is; on account of which, by just so many minutes more or less, he then attributed a larger obliquity to the Ecliptic, which exceeds by nearly a third part of a degree the greatest latitude of the Moon found by us at the quadratures: he was able to bring it out, that is, provided that in this *Pragmatia* he used only the northern limit near the tropic of Cancer.

In the same way, in the variation of the nodes too, we detect that no slight inequality underlies it, which nevertheless at the new and full moons, and then also at the quadratures, varies the mean motion imperceptibly — and so it is the less surprising that this diversity was not noticed by earlier astronomers, who observed the Moon chiefly around those places. But at the intermediate places it can increase or diminish by up to two degrees less a quarter on either side, so that the Moon's latitude itself can on this occasion be increased or diminished, near the nodes, by nearly a sixth part of a degree — that is, when one attends diligently to the mean place otherwise there. Of all which, in their own place and time, we shall furnish from various observations a further confirmation and explanation, God willing.

SCHEMA LATITUDINEM LUNAE DECLARANS.

Diagram. A schematic showing the variation of the Moon's orbital inclination and the motion of the nodes. The figure consists of a large outer circle with concentric and dashed orbital tracks, a vertical axis running from top (F) through the center to the bottom (P), and a small central construction of circlets around the Earth. The accompanying text (set to the right of the figure and continuing beneath it) is integrated into the description below.

- F (top of vertical axis): pole of the Ecliptic
- M (on axis, below F): point on the inner track
- N (on axis, below M): point on the inner track
- A, B (center region, on axis): the points marking the minimum inclination AB
- C, D, E, Q (small central circlet — the variation circle — around the Earth): C is the pole described from the center D of mean inclination; E is the pole of the Moon's orbit; Q is the right-rim point of the variation circle (the semicircle C Q B)
- G, O (lower vertical axis): G sits at the spindle waist on the axis, O below it, with P at the bottom — the axial segments F–M, A–B, and G–O are the equal minimum-inclination segments, and the diameters are M N and O P

- H (left side): node / left intersection point
- L (upper left, on dashed track): intersection point
- K (right side, on dashed track): intersection point
- P (bottom of vertical axis): lower pole point

The text reads: Let A, then, be the pole of the Ecliptic; FIGH the orbit of the Moon at new and full moons, in minimum inclination; NHPI the maximum, which occurs at the quadratures. CEB is the little circle of the variation of the Moon's path, described from the center D, the pole of mean inclination, in which E, the pole of the Moon's orbit, is moved according to the motion of the double distance of the Moon from the Sun; and at the quadratures it is found at C, where the greatest angle of inclination is reached.

And so, when the pole of the Moon's orbit is at E in this place — as it is at the first octant from conjunction — it follows that the Moon's orbit itself, which is marked by the dotted points, varies, and intersects the Ecliptic in one place and another, as it does at K and L; and thus the nodes vary, and move forward in the order preceding [in antecedentia]; until again at the quadratures they are united at I. And when the pole of the Moon's orbit shall have traversed the other semicircle CQB, the nodes are carried in consequence [in consequentia], until again, with the pole set at B, they are united.

But since in this hypothesis the minimum inclination AB — that is FM or GO, which occurs at conjunction and opposition, as we ascertain from observations — is $4^{\circ} 58' 30''$, and the maximum at the quadratures is $5^{\circ} 17' 30''$, as was said before, so that the difference is $19'$: namely the diameter BC, or MN. OP, it follows — both by observation and by the doctrine of triangles — that the greatest prosthaphaeresis of the nodes, which the angle DAE measures, is $1^{\circ} 46'$. This prosthaphaeresis, and the remaining variation of the Moon's latitude, we have arranged conveniently into the following tables; and we have demonstrated their use by four different examples, so that everything may be understood the more correctly.

TABULA PROSTHAPH. MODORUM. AD ⊕E.

The table gives the prosthaphaeresis of the nodes [Prosth. Nod.] in degrees, minutes, seconds (G, M, S) and the proportional minutes [Scr. Prop.] in minutes, seconds (M, S), as a function of the argument. The argument is read from the top headings (0/6, 1/7, 2/8) running downward, and from the bottom headings (11/5, 10/4, 9/3) running upward; the table is additive on the top set and subtractive on

the bottom (SUBTR. at foot). The argument-row index (0–30) is the first cell of each line.

0 / 6 — Prosth. Nod. G	Scr. Prop. M	1 / 7 — Prosth. Nod. G	Scr. Prop. M	2 / 8 — Prosth. Nod. G	M	Scr. Prop. M
0	0	1	15	1	3 0	45
0	0	1	16	1	2 8	46
0	0	1	17	1	2 6	47
0	0	1	18	1	2 4	47
0	0	1	19	1	2 2	48
0	0	1	20	1	1 9	49
0	0	1	21	1	1 7	50
0	0	1	22	1	1 4	51
0	1	1	23	1	1 2	51
0	1	1	24	1	9	52
0	1	1	25	1	6	53
0	2	1	26	1	3	53
0	2	1	27	1	0	54
0	3	1	28	0	5 7	54
0	3	1	29	0	5 4	55
0	4	1	30	0	5 1	56
0	4	1	31	0	4 8	56

0 / 6 — Prosth. Nod. G	Scr. Prop. M	1 / 7 — Prosth. Nod. G	Scr. Prop. M	2 / 8 — Prosth. Nod. G	M	Scr. Prop. M
1	5	1	32	0	4	57
					5	
1	5	1	33	0	4	57
					2	
1	6	1	34	0	3	57
					3	
					[?	
					]	
1	7	1	35	0	3	58
					5	
1	7	1	36	0	3	58
					1	
1	8	1	37	0	2	58
					8	
1	9	1	38	0	2	59
					4	
1	10	1	39	0	2	59
					1	
1	11	1	40	0	1	59
					7	
1	11	1	41	0	1	59
					4	
1	12	1	42	0	1	59
					0	
1	13	1	43	0	7	59
1	14	1	44	0	3	59
1	15	1	45	0	0	60

Bottom argument headings (read upward): for column block 1 — 11 / 5; for block 2 — 10 / 4; for block 3 — 9 / 3. Foot label: SUBTR.

TABLE OF THE LATITUDE OF THE MOON [TABULA LATITUDINIS LUNAE]

The table carries three argument-blocks across the page. Each block is headed at the top by two zodiac-position labels and at the foot by two more, indicating which sign-argument and which direction (Bor. = *Borealis*, northern; Mer. = *Meridionalis*, southern; A = adding/*addenda*, D = subtracting/*demenda*) applies when reading the column downward (top labels, argument 0→30) versus upward (foot labels, argument 30→0). Each block contains a **Latitudo** sub-table (degrees G, minutes M, seconds S) and an **Excessus** sub-table (minutes M, seconds S). The leftmost column is the entering argument (0–30); the rightmost column is the complementary argument (30–0) read for the foot labels.

Top labels, left to right:

- Block 1: **0 Bor. A / 6 Mer. D**
- Block 2: **1 Bor. A / 7 Mer. D**
- Block 3: **2 Bor. A / 8 Mer. D**

Foot labels, left to right:

- Block 1: **11 Mer. A / 5 Bor. D**
- Block 2: **10 Mer. A / 4 Bor. D**
- Block 3: **9 Mer. A / 3 Bor. D**

	B1		B1		B2		B2		B3		B3		B3		B3		A
Arg	B1	La	B1	Ex	B1	B2	La	B2	Ex	B2	B3	La	B3	Ex	B3	Ex	rg
.↓	t G	t M	t S	c M	c S	t G	t M	t S	c M	c S	t G	t M	t S	c M	c S	c S	.↑
0	0	0	0	0	0	2	29	6	9	28	4	18	26	16	25	30	
1	0	5	13	0	20	2	33	36	9	45	4	20	59	16	35	29	
2	0	10	25	0	40	2	33	3	10	2	4	23	28	16	45	28	
3	0	15	36	0	59	2	42	26	10	18	4	25	53	16	55	27	
4	0	20	47	1	19	2	46	46	10	35	4	28	13	17	4	26	
5	0	25	58	1	39	2	51	4	10	51	4	30	28	17	12	25	
6	0	31	9	1	59	2	55	19	11	7	4	32	38	17	20	24	
7	0	36	19	2	19	2	59	30	11	23	4	34	43	17	28	23	
8	0	41	29	2	38	3	3	38	11	39	4	36	43	17	36	22	
9	0	46	38	2	57	3	7	43	11	55	4	38	38	17	43	21	

	B1		B1		B2		B2		B3		B3					
A	B1	La	B1	Ex	B1	B2	La	B2	Ex	B2	B3	La	B3	Ex	B3	A
rg	La	t	La	c	Ex	La	t	La	c	Ex	La	t	La	c	Ex	rg
.↓	t G	M	t S	M	c S	t G	M	t S	M	c S	t G	M	t S	M	c S	.↑
10	0	51	46	3	17	3	11	44	12	11	4	40	27	17	51	20
11	0	56	53	3	36	3	15	42	12	26	4	42	11	17	58	19
12	1	1	59	3	55	3	19	36	12	41	4	43	50	18	5	18
13	1	7	4	4	15	3	23	26	12	56	4	45	23	18	12	17
14	1	12	8	4	34	3	27	13	13	10	4	46	52	18	18	16
15	1	17	10	4	53	3	30	56	13	24	4	48	18	18	23	15
16	1	22	11	5	13	3	34	35	13	38	4	49	35	18	27	14
17	1	27	10	5	32	3	38	10	13	52	4	50	49	18	31	13
18	1	32	8	5	51	3	41	42	14	5	4	51	58	18	34	12
19	1	37	4	6	10	3	45	7	14	18	4	53	0	18	38	11
20	1	41	58	6	29	3	48	30	14	31	4	53	57	18	42	10
21	1	46	51	6	47	3	51	52	14	44	4	54	49	18	45	9
22	1	51	41	7	6	3	55	9	14	57	4	55	36	18	48	8
23	1	56	30	7	24	3	58	19	15	9	4	56	17	18	51	7
24	2	1	17	7	42	4	1	23	15	21	4	56	52	18	53	6
25	2	6	1	8	0	4	4	24	15	32	4	57	22	18	55	5
26	2	10	43	8	18	4	7	21	15	43	4	57	46	18	56	4
27	2	15	23	8	35	4	10	15	15	54	4	58	5	18	57	3
28	2	20	0	8	53	4	13	5	16	5	4	58	18	18	58	2
29	2	24	34	9	11	4	15	49	16	15	4	58	26	18	59	1
30	2	29	6	9	28	4	18	26	16	25	4	58	30	19	0	0

ON DERIVING THE TRUE LATITUDE OF THE MOON FROM THE TABLES [DE LATITUDINE LUNAE VERA EX TABULIS ERUENDA]

For the proposed moment — that for which the Moon's longitude has been computed — first have ready the simple motion of latitude and the true distance of the luminaries, together with the absolute prosthaphaeresis of the Moon's mean motion of latitude. Add this to, or subtract it from, the mean motion of

latitude, according to what the indication of the column-titles requires, so that you obtain the true value. Then, with the true distance of the Moon and Sun, take from the earlier table the proportional minutes [*scrupula proportionalia*] that are to be retained, and the prosthaphaeresis of the nodes; and, just as the titles direct you to add or subtract, add it to or remove it from the true motion of latitude, so that the coequated motion of latitude results.

By means of this, from the later table, take out the latitude of the Moon together with its excess [*excessus*] — applying always the correction, if proportional minutes attach to the coequated motion of latitude — taking each appropriately. The proportional minutes, then, multiplied into the excess, yield the proportional part that is always to be added to the latitude, so that the true latitude with respect to this inclination of the Moon's orbit and the ecliptic emerges. Whether this latitude is northern [*Borea*] or southern [*Austrina*] the titles set at the head and foot of the table indicate plainly.

FIRST EXAMPLE [PRIMUM EXEMPLUM]

In the year 1596, on 4 January, at 11 hours 43 minutes after midday, the latitude of the Moon was observed as $4^{\circ} 31' 3''$ [as seen, *visa* 4 P. 31 / Sept.]. To this its parallax, $28' 3''$, being added, the true latitude is established as $4^{\circ} 59' 3''$. For the proposed moment the mean motion of latitude is gathered as 3 signs $4^{\circ} 58' 46''$, from which the absolute prosthaphaeresis $5^{\circ} 4' 19''$ being subtracted, there remains the true motion of latitude from the mean node, 2 signs $29^{\circ} 54' 27''$. Then, since the true distance of the luminaries is 5 signs $23^{\circ} 38' 4''$, I enter the earlier little table, and find proportional minutes 46 to be retained, and the prosthaphaeresis of the nodes $24' 8''$ to be subtracted from the true motion of latitude, so that it may be coequated; and it comes to 2 signs $29^{\circ} 54' 27''$ [recte 2 S. 29 P. 30 / 19?]. With this I enter the table of latitude, taking out the latitude and the excess — the due correction by the proportional part having been made — and I find the latitude $4^{\circ} 58' 28''$ and the excess $19' 0''$. The retained proportional minutes 46, logistically multiplied, yield $14''$, always to be added to the latitude, as was said, so that the absolute value emerges as $4^{\circ} 58' 43''$ northern; which differs from the observed value only by about a third of one minute — a thing of no moment.

SECOND EXAMPLE [SECUNDUM EXEMPLUM]

In the year 1587, in the month of August, on the 18th day, at 7 hours 25 minutes before midday, the Moon was observed in quadrature, having a true latitude of $5^{\circ} 13' 15''$ southern [*Merid.*]. To the coequated time there corresponds the mean

motion of latitude 9 signs $0^{\circ} 57' 20''$. From this let the absolute prosthaphaeresis of the Moon, $4^{\circ} 40' 14''$, be subtracted, and there remains

the true motion of latitude 8 signs $26^{\circ} 17' 6''$. But with the true distance of the luminaries being 9 signs $22^{\circ} 18' 8''$, I draw from the earlier table the proportional minutes $51' 34''$ [as printed: $51/34$] to be retained, and the prosthaphaeresis of the nodes $1^{\circ} 12' 57''$ to be subtracted, so that the coequated motion of latitude may remain, 8 signs $25^{\circ} 4' 9''$. To this in the table of latitude there responds the corrected latitude $4^{\circ} 57' 24''$, and the excess $18' 55''$; which, multiplied into the retained proportional minutes, produces the proportional part $16' 15''$ [as printed] to be added to the latitude, so that the true latitude emerges, $5^{\circ} 13' 39''$ southern — which differs altogether imperceptibly from the observed value.

THIRD EXAMPLE [TERTIUM EXEMPLUM]

In the year 1592, on the 12th day of February, at 8 hours 12 minutes, the true latitude of the Moon was observed as $16' 5''$ [$16 / 5$]. For that moment the equal motion of latitude is gathered as $0^{\circ} 54' 23''$ [Cæ $54/23$]. The absolute prosthaphaeresis is $3^{\circ} 36' 45''$. Add it, so that the true motion comes out as $4^{\circ} 31' 8''$. The true distance of the luminaries is 4 signs $4^{\circ} 13' 11''$; from the table is supplied the proportional minutes $41' 25''$ to be retained, and the prosthaphaeresis of the nodes $1^{\circ} 53' 32''$. With this, from the table of latitude there is drawn out the latitude of the Moon $15' 3''$ northern, and the excess $57''$; which, drawn into the proportional minutes, produces $39''$ as the proportional part. This, added to the latitude previously established, constitutes the true latitude $15' 42''$ northern. Because the third part is only of one minute, having no moment, it falls short of the observed value. But if the prosthaphaeresis of the nodes had been neglected, the latitude from the tables would have been $24'$, which differs from the observation by more than 8 minutes.

FOURTH EXAMPLE [QUARTUM EXEMPLUM]

In the year 1595, on the 18th day of February, at hour 5, minute 43 before midday, the true latitude was observed as $5^{\circ} 7' 20''$ northern. The mean motion of latitude is 5 signs $21^{\circ} 39' 15''$. The absolute prosthaphaeresis of the Moon is $5^{\circ} 34' 53''$. Add it, so that the true value emerges, 5 signs $27^{\circ} 14' 8''$. The true distance of the luminaries, 7 signs $22^{\circ} 55' 34''$, shows the proportional minutes $38' 38''$ to be retained, and the prosthaphaeresis of the nodes $1^{\circ} 41' 15''$. Add it, so that the coequated value comes out, 5 signs $28^{\circ} 55' 23''$; which, sent into the table of latitude, shows $5^{\circ} 37'$ [$5/37$], and the excess $30''$. Concerning this, from the retained proportional minutes the proportional part $19''$ is to be added, so that the

true latitude is $5^{\circ} 56'$ northern — which is distant from the observed value by half a minute. Had the prosthaphaeresis of the nodes been omitted, the latitude would have come out as $14'$ [recte $5^{\circ} 41'?$], exceeding the true by 8 minutes [as printed; reading uncertain].

But lest the reader should lack what concerns the unfolding and demonstration of our hypothesis in the motion of latitude, here is an example of how the latitude of the Moon is to be computed from triangles — something we judged should be added. We shall keep, however, the same procedure we used before in the triangular demonstration.

Diagram. A circle with vertical diameter. From an upper point C a long line descends, passing through the center D and continuing well below the circle to a lower point A; the line crosses the circle's lower edge at B. A point F lies on the circle at the upper left, and lines run from F to D and from F to C; a point E lies at the right of the circle. The figure illustrates the spherical-triangle reduction of the Moon's latitude.

- C (top, on the circle): upper terminus of the diameter
- F (upper left, on the circle): apex from which the inclination angle is measured
- D (center): center of the circle
- E (right, on the circle): point on the circumference
- B (lower, where line meets circle): foot of the diameter on the circle
- A (far below, outside the circle): lower terminus of the descending line

In this configuration, then, let **AD** be the mean inclination of the Moon's orbit to the ecliptic, $5^{\circ} 8'$; let **AB** be understood as the minimum inclination; and **CA** the maximum. The true distance of the luminaries, doubled, is reckoned from B through E up to C as 7 signs $14^{\circ} 36' 19''$. Now in triangle **FDA** the side **DA** is given, $5^{\circ} 8'$ — namely the mean inclination of the Moon's orbit — and the side **DF**, the semi-difference of the maximum and minimum inclination, $9' 30''$, together with the included angle **FDA**, which is the complement of double the Moon's longitude from the Sun, taken up to a whole circle: 4 signs $15^{\circ} 23' 44''$. There is therefore given, by the doctrine of spherical triangles, the angle **FAD**, the prosthaphaeresis of the nodes, $1^{\circ} 12' 57''$ — which in this place is to be subtracted from the mean motion of latitude — and the side **FA**, $5^{\circ} 14' 50''$, the angle of inclination of the Moon's path to the ecliptic. The true motion of latitude, with the absolute prosthaphaeresis $4^{\circ} 40' 14''$ subtracted, from which again the prosthaphaeresis of the nodes $1^{\circ} 12' 57''$ is taken away, leaves the coequated value 8 signs $25^{\circ} 4' 9''$.

Now, if the whole sine be 1,000,000, then to the sine of the angle of inclination $5^{\circ} 14' 50''$ there is 0.0914533 [014533]; and so the sine of the Moon's distance from the node, 3 signs $4^{\circ} 54' 51''$ — that is, 0.9963204 [9963204] — to the sine of the Moon's latitude, 0.0911168 [911168]. To this responds the arc $5^{\circ} 13' 49''$ northern. Here, if the prosthaphaeresis of the nodes had been omitted, the latitude found would have been $4^{\circ} 57' 51''$ [4 P. 57 / 51], so that the difference would be $15' 49''$. From the foregoing examples, then, it is clear that the diversity in the Moon's latitude which we have asserted has its place not only about the maximum limits, but also perceptibly near the nodes; and that the Moon's appearances cannot be exhibited otherwise than as has been observed by our predecessors. From this it is also evident that this hypothesis of ours, and the numbers built upon it, agree quite exactly with the celestial observations.

ON THE METHOD OF INVESTIGATING THE NODES [DE MODO INVESTIGANDI NODOS]

Having now explained the involved theory of the Moon's latitude, let us inquire into the nodes, where the Moon — being entirely free of latitude — crosses the ecliptic. It will be worth the

is correct. For the northern node, then, which is opposite to the remaining one, the simple motions for the given time should be set out: the simple motion of the Sun [Simplex $\odot$] from the equinox, the simple motion of the Moon [simplex $\lrcorner$] from the Sun, and the simple motion of the Moon's latitude [simplex motus latitudinis $\lrcorner$]. Joining these, add the simple motion of the Sun to the simple motion of the Moon, so as to compose the Moon's simple longitude from the vernal equinox. From this aggregate subtract again the simple motion of the Moon's latitude, and you will obtain the mean anticipation of the nodes [anticipatio Nodorum media] — very nearly what those who follow Ptolemy [Ptolemaeus], Alfonso [Alphonsus], and Copernicus commonly use, persuaded — wrongly — that no inequality underlies it here. But so that this may be tempered in the proper way, take the equation of the nodes [aequatio nodorum] from the table of prosthaphaereses by way of the true distance of the luminaries [distantia Luminarium vera]; then, in the contrary manner — as the very headings of the table indicate — add it to or subtract it from the mean motion of the nodes. In this way you will arrive at the true place of the node, the one carrying the Moon toward the north, which they call the Head of the Dragon [caput Draconis]; the other node, which they name the Tail of the Dragon [Cauda Draconis], is, as has been said, set diametrically opposite. Both limits of the maximum latitudes are,

moreover, removed a quarter of a circle on either side from these points, should one wish to know them as well.

EXEMPLUM.

In the third example, which we used in investigating the Moon's latitude, the simple motion of the Sun [simplex ☉] is 11s 1° 51' 1". To this is added the mean motion of the Moon from the Sun [Medius ☽ à ☉] 4s 2° 20' 59", which constitutes the simple motion of the Moon [Simplex ☽] from the vernal equinox 3s 4° 12' 0". From this, the simple motion of the latitude [Simplex Latitudinis] 54° 23' being subtracted, there remains the mean anticipation of the nodes [media nodorum anticipatio] 3s 3° 17' 37". Now with the distance of the luminaries [distantia Luminarium] being 4s 4° 13' 11", the prosthaphaeresis of the nodes [Prosthaphaeresis Nodorum] is derived as 1° 37' 36"; this, in the place marked "Add" [Addenda], is added to the mean motion of the nodes, so that the true place [verus locus] is constituted as 3s 4° 55' 13".

Alternatively, if you have the Moon's longitude [Longitudo ☽] as well as its collected latitude [Latitudo collecta], subtract the equated motion of the latitude [coaequatus motus Latitudinis], which you used in extracting the latitude, from the Moon's true place [verus locus ☽], and there will remain the true place of the Head of the Dragon [verus locus Capitis Draconis]. Thus in the same example the Moon's true place [verus locus ☽] is 3 signs 7° 49' 45"; from this, the equated latitude [coaequatus Latitudinis] 2° 53' 32" being subtracted, the true place of the [Head of the] Dragon [verus locus ☾ {recte: ☿}] remains as 3s 4° 55' 13". This exceeds the Alphonsine [Alphonsinus] and Copernican reckoning by a degree and a half, as the Prutenic Tables [tabulae Prutenicae] give it, by 11 minutes. The discrepancy is somewhat more in minutes — which, around the Moon's very nodes, is indeed an intolerable difference.

DE REDUCTIONE LOCI LUNAE AD ECLIPTICAM.

Since the Moon's motion does not proceed beneath the ecliptic, but in some other circle inclined to it — while the calculation yields the motion that takes place in the Moon's own orbit, not the one that the instruments furnish by observation with respect to the ecliptic and its poles — some adjustment is therefore needed here, which is most easily provided by an adjoined little table, in this manner.

Table: Reduction of the Moon to the Ecliptic [Reductio Lunae ad Eclypticam].

The table is bordered on the left and right by a vertical column reading **Verus Motus** ("True Motion"), giving the argument 0–30 down the page. The body

columns are headed by paired sign-numbers (0 | 1 | 2 across the top, 6 | 7 | 8 below, with "S" between), each split into M (minutes) and S (seconds). At the foot, paired columns are headed 11 | 10 | 9 and 5 | 4 | 3, with **Lat.** ("Latitude") on the left and right margins, and the plate is signed **A.** below.

Verus Motus	0 / 6 (S) M	S 1 / 7 (S) M	S	2 / 8 (S) M	S
0	0	0 6	6	5	30
1	0	1 6 5	12	5	57
2	0	3 6 0	18	5	48
3	0	4 6 5	24	5	39
4	0	5 6 9	29	5	30
5	1	1 6 3	35	5	21
6	1	2 6 7	40	5	12
7	1	4 6 2	44	5	1
8	1	5 6 6	47	4	51
9	2	1 6 0	51	4	40
10	2	2 6 4	54	4	29
11	2	3 6 3	56	4	18
12	2	5 6 2	57	4	7
13	3	6 6	58	3	55
14	3	1 6 9	59	3	42
15	3	3 7 2	0	3	31

Verus Motus	0 / 6 (S) M	S 1 / 7 (S) M	S	2 / 8 (S) M	S
16	3	4 6 3	59	3	18
17	3	5 6 6	58	3	5
18	4	8 6	57	2	51
19	4	1 6 9	56	2	38
20	4	3 6 0	54	2	23
21	4	4 6 1	51	2	9
22	4	5 6 2	47	1	55
23	5	2 6	44	1	41
24	5	1 6 3	40	1	26
25	5	2 6 2	35	1	12
26	5	3 6 1	23 [?]	0	58 [?]
27	5	4 6 0	23	0	45
28	5	4 6 9	17	0	30
29	5	5 6 8	11	0	15
30	6	6 6	5	0	0

Foot of table (paired argument-headings, single value-row): under **11** | **10** | **9** the value **5** | **4** | **3**; signed **A**.

The right-hand text column reads:

When you wish to reduce the Moon's place [locus ☾], calculated from our tables, from its own proper orbit to the ecliptic, I enter the adjoined table with the true and equated motion [verus et coaequatus motus], looking — in the customary

manner — for the sign at the head or foot, and the degree; then, ascending or descending, and with the minutes together with the seconds found in the common angle, I add or subtract from what is found, by computation, for the Moon's place [loco Lunae], so that I obtain its true situation with respect to the ecliptic.

I do the contrary with these headings A and S when the Moon's place, observed by instruments from the ecliptic and its poles, is to be reduced to its own proper orbit. By this concise reckoning we shall nowhere err by more than half a scruple [scrupulum] either way. But if you wish to pursue the highest precision, take for the angle $5^{\circ} 8'$ — which we have used in the construction of this table as though it were invariable — the true latitude [latitudo vera] at the given time intended; and, according to the doctrine of spherical triangles [doctrina sphaericorum triangulorum], seek either from both sides and the base, or from the base and the side of latitude, the side of longitude — as need will require.

DE VARIA LUNAE A TERRA DISTANTIA, ET HINC DEDUCTIS EIUS PARALLAXIBUS.

That the Moon does not always keep one and the same distance from the Earth has been established from the variation of its parallax [Parallaxis]. The hypothesis of its motion, devised to account for the inequalities of longitude, requires this very thing as well — although in this part, and in most others, our predecessors were not, it appears, sufficiently attentive, as Experience itself, drawn from the heavens, attests. For if we accept what was handed down by Ptolemy [Ptolemaeus] and those most ancient authors, the Moon would have to vary its distance of removal from the Earth by $30\frac{2}{3}$ Earth-radii [semidiametri Terrae] — which by no means agrees with its appearances; or if one supposes an alteration of the apparent diameter...

which cannot be so great as this reasoning demands, or if one scrutinizes the discrepancies of the parallaxes. That distinguished man Copernicus did indeed notice this to some extent, and Regiomontanus before him; but neither of them applied the remedy this inconsistency required. Regiomontanus, plainly, none at all; Copernicus, indeed, one not yet sufficient. For although he conceived an hypothesis of the lunar motion more apt than was previously in use, he nonetheless, by that very means, admitted too large and ill-considered wanderings of the Moon away from the Earth; while as to the rest — what concerns the longitude and latitude of the Moon — he excused them by the same hypothesis less aptly, as is clear from what was said above; I shall not repeat it

here. For it follows from his hypothesis that the Moon can alter its distance by as much as 16 complete Earth-radii [terrae semidiametri], for which experience gives no support whatever.

For we have observed, with careful balance applied, that the Moon, when in the quadratures [Quadraturae] it is most removed, is no farther off than $60\frac{1}{2}$ Earth-radii [semidiametri terrae]. And when in the same quadratures it is nearest, it is found to come no closer than $52\frac{2}{5}$ radii [semidiametri], so that the whole difference between the most-remote and nearest elongation is only $8\frac{5}{6}$ radii — which the parallax observations do not allow to be greater, but rather somewhat less. From this it becomes manifest that Copernicus made this difference twice as large as it ought to have been, while Ptolemy made it not much beyond half of it, as he affirms. But that our reasoning about the distances of the Moon from the Earth agrees better with the observations and with the renewed hypothesis, and that the comparison of the same with the opinions of Ptolemy and Copernicus may be more readily evident, I subjoin a little table explaining all these matters at once, which sets forth before the eyes the diversities both of the parallax and of the apparent diameter of the Moon.

Table: Various dispositions of the Moon in its [our] hypothesis [Variae dispositiones Lunae in sua hypothesi]. Three groups of columns: "According to our invention [iuxta nostram inventionem]," "According to Copernicus [iuxta Copernicum]," and "According to Ptolemy [iuxta Ptolemaeum]." Each group gives Distance in radii [Dist. in se(midiametris)], Parallax in hours [Para. in Hor.], and Apparent diameter [Diam. app.].

Disposition of the Moon	Our			Coper.:			Cope			Ptol.:		
	Ours: Dist. (semi d.)	Ours: Parall. (Hor.)	s: Dia m. app.	Coper.: Dist. (semid .)	Coper.: Parall. (Hor.)	Cope r.: Diam . app.	Ptol.: Dist. (semi d.)	Ptol.: Parall. (Hor.)	Ptol.: Dia m. app.			
Moon most remote, in conjunction & opposition (Ptolem	60 36	56 44	32 32	68 21	50 19	27 40	64 10	0 54	29 0			

Disposi tion of the Moon	Ours: Dist. (semi d.)	Ours: Parall (Hor.)	Our s: Dia m. app.	Coper.: Dist. (semid)	Coper.: Parall. (Hor.)	Cope r.: Diam . app.	Ptol.: Dist. (semi d.)	Ptol.: Parall. (Hor.)	Ptol.: Dia m. app.
y) [☽ remotis s. Ptol. in ☿ & ♂] — Coper. & ours in quadra ture [in ☐ Moon most remote in conjunc tion & opposit ion [☽ remotis s. in ☿ & ♂]									
	58 8	59 9	33 9	55 30	52 56	30 0	43 53	1 18	42 8
Mean distanc e [Media distanti a]	56 30	60 51	34 0	60 29	58 25	32 50	48 51	1 10	38 42
Moon in conjunc tion & opposit	54 52	61 39	34 48	55 8	62 54	35 40	3 50 [?]	1 4	36 8

Disposi tion of the Moon	Ours: Dist. (semi d.)	Ours: Parall (Hor.)	Our s: Dia m. app.	Coper.: Dist. (semid)	Coper.: Parall. (Hor.)	Cope r.: Diam . app.	Ptol.: Dist. (semi d.)	Ptol.: Parall. (Hor.)	Ptol.: Dia m. app.
ion nearest [$\oslash$ in σ & $\oslash$ proxim i T(errae)]									
Moon in quadra ture nearest the Earth [$\oslash$ in $\square$ proxim a Ter.]	52 14	65 36	36 0	52 17	65 48	36 8	33 33	1 42	55 0
Differe nce [Differe ntia]	3 12	8 52	4 0	16 4	15 29	8 28 [?]	30 37	0 46	26 0

From this, then, the Moon is not brought closer to the Earth than the interval of 52 radii [semidiametri], nor farther than 61 radii — within which limits we have constructed the Parallax Table for each single radius of its removal, and extended over all the degrees of the quadrant from the horizon to the vertex. For in this way we judged that the Lunar Parallaxes could be consulted universally, and by a simpler and easier compendium than has been customary with others. Now we shall append the said table, intending afterward to set out its use.

TABULA PARALLAXIUM LUNARIUM.

Table of Lunar Parallaxes.

Top headings — the radius-of-distance arguments, running across in ten columns:
52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61.

Sub-heading: **Distantia ☽æ à Terra in partibus semidiametri Eccentrici**
100000 ("Distance of the Moon from the Earth in parts of the radius of the
eccentric, 100000").

Beneath each radius-argument, the corresponding distance in those parts (left-to-
right under 52...61): **92028 | 93798 | 95568 | 97337 | 99107 | 100877 | 102647 |**
104416 | 106186 | 107956

Each of the ten columns is split into M (minutes) and S (seconds). The left-hand
argument column runs 0–30 (degrees of altitude/zenith-distance argument).

A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6		
r	2	2	3	3	4	4	5	55	6	56	7	57	8	58	59	59	0	60	1	61
g	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
0	6	6	6	5	6	3	6	30	6	23	6	20	5	17	58	16	5	18	5	21
	6		4	1	3	9	2		1		0		9			7		6		
1	6	6	6	5	6	3	6	29	6	23	6	19	5	17	58	16	5	18	5	21
	6		4	1	3	9	2		1		0		9			7		6		
2	6	5	6	5	6	3	6	28	6	22	6	18	5	16	58	15	5	17	5	19
	6		4	0	3	8	2		1		0		9			7		6		
3	6	4	6	5	6	3	6	26	6	21	6	17	5	15	58	14	5	16	5	19
	5		4	0	3	8	2		1		0		9			7		6		
4	6	1	6	4	6	3	6	25	6	18	6	15	5	13	58	11	5	13	5	16
	6		4	7	3	5	2		1		0		9			7		6		
5	6	5	6	4	6	3	9	21	6	14	6	11	5	8	58	7	5	9	5	13
	5	7	4	3	3	1	2		1		0		9			7		6		
6	6	5	6	3	6	2	6	16	6	10	6	7	5	3	58	3	5	5	5	5
	5	2	4	8	3	6	2		1		0		9			7		7		
7	6	4	6	3	6	2	6	10	6	4	6	1	5	57	57	58	5	0	5	4
	5	6	4	2	3	0	2		1		0		8		[?]	[?]	7		6	
8	6	3	6	2	6	1	6	3	6	57	5	54	5	50	57	51	5	53	5	57
	5	8	4	4	3	2	2		0		9		8			6		5		
9	6	2	6	1	6	3	6	54	6	48	5	46	5	42	57	43	5	44	5	48
	5	9	4	5	3		1		0		9		8			6		5		
1	6	1	6	5	6	5	6	45	6	39	5	37	5	33	57	34	5	35	5	39

A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6		
r	2	2	3	3	4	4	5	55	6	56	7	57	8	58	59	59	0	60	1	61	
g	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	
0	5	9	4		2	3	1		0		9		8				6		5		
1	6	8	6	5	6	4	6	34	6	28	5	27	5	23	57	24	5	25	5	29	
1	5		3	4	2	2	1		0		9		8				6		5		
1	6	5	6	4	6	3	6	22	6	16	5	16	5	12	57	13	5	14	5	18	
2	4	5	3	1	2	0	1		0		9		8				6		5		
1	6	4	6	2	6	1	6	9	6	3	5	3	5	59	57	1	5	2	5	6	
3	4	1	3	8	2	7	0		0		9		7				6		5		
1	6	2	6	1	6	3	6	55	5	49	5	48	5	45	56	47	5	49	5	52	
4	4	6	3	4	2		0		9		8		7				5		4		
1	6	1	6	5	6	4	6	39	5	34	5	32	5	30	56	32	5	35	5	36	
5	4	0	2	7	1	7	0		9		8		7				5		4		
1	6	5	6	4	6	3	6	22	5	18	5	16	5	14	56	16	5	20	5	22	
6	3	3	2	0	1	1	0		9		8		7				5		4		
1	6	3	6	2	6	1	5	4	5	1	5	58	5	57	56	0	5	4	5	6	
7	3	5	2	2	1	3	9		9		7		6				5		4		
1	6	1	6	3	6	5	5	58	5	42	5	40	5	40	55	43	5	47	5	49	
8	3	5	2		0	4	9	[?]	8	[?]	7	[?]	6	[?]		[?]	4		3		
1	6	5	6	4	6	3	5	27	5	22	5	21	5	21	55	24	5	29	5	34	
9	2	4	1	3	0	4	9		8		7		6				4		3		
2	6	3	6	2	6	1	5	6	5	1	5	1	5	1	55	4	5	10	5	14	
0	2	2	1	1	0	2	9		8		7		6				4		3		
2	6	8	6	5	5	4	5	44	5	40	5	40	5	40	54	44	5	50	5	55	
1	2		0	8	9	9	8		7		6		5				3		2		
2	6	4	6	3	5	2	5	21	5	18	5	18	5	18	54	22	5	23	5	35	
2	1	4	0	4	9	6	8		7		6		5				3	[?]	2	[?]	
2	6	1	6	9	5	2	5	57	5	54	5	54	5	54	53	59	5	5	5	13	
3	1	9	0		9		7		6		5		4			[?]	3	[?]	2		
2	6	5	5	4	5	3	5	31	5	29	5	29	5	29	34	3	5	40	5	50	
4	0	2	9	2	8	6	7		6	[?]	5		4		[?]	[?]	2	[?]	1		
2	6	2	5	1	5	9	5	5	5	3	5	4	5	4	53	9	5	15	5	27	
5	0	4	9	5	8		7		6		5		4				2		1		
2	5	5	5	4	5	4	5	38	5	36	5	38	5	39	52	44	5	50	5	3	

A	5	5	5	5	5	5	5		5		5		5				6		6		
r	2	2	3	3	4	4	5	55	6	56	7	57	8	58	59	59	0	60	1	61	
g	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	
6	9	5	8	7	7	1	6		5		4		3				1		1		
2	5	2	5	1	5	1	5	10	5	8	5	11	5	13	52	18	5	25	5	38	
7	9	5	8	7	7	2	6		5		4		3				1		0		
2	5	5	5	4	5	4	5	40	5	39	5	42	5	45	51	51	5	59	5	11	
8	8	4	7	6	6	2	5		4		3		2				0		0		
2	5	2	5	1	5	1	5	9	5	9	5	12	5	16	51	23	5	32	4	43	
9	8	2	7	4	6	1	5		4		3		2				0		9		
3	5	4	5	4	5	3	5	37	5	38	5	42	5	47	50	54	5	5	4	13	
0	7	3	6	2	5	9	4		3		2		1				0	[?]	9		

[Compositor error flagged: p. 160, Tabula Parallaxium Lunarium, arg-row 5, col 55 (radius 97337): minutes = "92", printed as such; breaks the col-55 minutes run (62→[92]→62). Compositor error in the tens digit (intended 62). Seconds = 21 (in range) — not a seconds-impossible.]

TABLE OF LUNAR PARALLAXES [TABULA PARALLAXIUM LUNARIUM]

(Continuation. The table is laid out with the altitude-argument running down the left margin and ten columns of parallax across the top, one for each value of the Moon's distance. The ten column-group headers give first the radius-argument 52–61, then the corresponding distance of the Moon from the Earth "in parts of the semidiameter of the eccentric, 100000" [Distantia Lunae à Terra in partibus semidiametri Eccentrici 100000]: 92028, 93798, 95568, 97337, 99107, 100877, 102647, 104416, 106186, 107956. Each distance column is subdivided into minutes [M] and seconds [S]. The page 160 portion — altitude-arguments 0–30 — is recovered separately; the rows below begin at 31.)

altitude-arguments 31–60

Column-group headers (radius-argument / distance): 52 / 92028, 53 / 93798, 54 / 95568, 55 / 97337, 56 / 99107, 57 / 100877, 58 / 102647, 59 / 104416, 60 / 106186, 61 / 107956.

A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
r	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	0	0	1	1
g.	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
3	5	1	5	9	5	1	5	4	5	6	5	1	5	1	5	2	4	3	4	4
1	7	3	6		5	6	4		3		2	0	1	6	0	4	9	5	8	3
3	5	3	5	2	5	3	5	3	5	3	5	3	5	4	4	5	4	7	4	1
2	6	8	5	4	4	2	3	0	2	3	1	7	0	4	9	2	9		8	3
3	5	2	5	5	5	5	5	5	5	5	5	4	5	1	4	1	4	3	4	4
3	6		4	8	3	7	2	5	1	9	1		0	0	9	9	8	4	7	2
3	5	2	5	2	5	2	5	2	5	2	5	3	4	3	4	4	4	0	4	1
4	5	5	4	1	3	1	2	0	1	4	0	0	9	5	8	6	8		7	0
3	5	4	5	4	5	4	5	4	5	4	4	5	4	5	4	1	4	2	4	3
5	4	6	3	3	2	3	1	4	0	8	9	5	8	9	8	2	7	5	6	7
3	5	5	5	4	5	4	5	7	5	1	4	1	4	2	4	3	4	4	4	2
6	4		3		2		1		0	1	9	8	8	2	7	7	6	9	6	
3	5	2	5	2	5	2	5	2	4	3	4	4	4	4	4	1	4	1	4	2
7	3	4	2	4	1	4	0	9	9	3	8	1	7	6	7		6	4	5	7
3	5	4	5	4	5	4	4	4	4	5	4	3	4	9	4	2	4	3	4	5
8	2	2	1	3	0	4	9	9	8	4	8		7		6	4	5	8	4	1
3	5	0	5	1	5	3	4	8	4	1	4	2	4	3	4	4	4	0	4	1
9	2		1		0		9		8	5	7	4	6	1	5	6	5		4	5
4	5	1	5	1	4	2	4	2	4	3	4	4	4	5	4	8	4	2	4	3
0	1	7	0	8	9	1	8	7	7	5	6	4	5	3	5		4	2	3	8
4	5	3	4	3	4	3	4	4	4	5	4	3	4	1	4	2	4	4	4	0
1	0	2	9	4	8	8	7	5	6	3	6		5	4	4	8	3	3	3	
4	4	4	4	4	4	5	4	2	4	1	4	2	4	3	4	4	4	4	4	2
2	9	6	8	9	7	4	7		6	0	5	4	4	4	3	7	3		2	1
4	4	5	4	3	4	9	4	1	4	2	4	3	4	5	4	6	4	2	4	4
3	8	9	8		7		6	8	5	7	4	8	3	2	3		2	4	1	1
4	4	1	4	1	4	2	4	2	4	4	4	5	4	8	4	2	4	4	4	0
4	8	1	7	6	6	3	5	3	4	3	3	4	3		2	4	1	3	1	
4	4	2	4	2	4	3	4	4	4	5	4	1	4	2	4	4	4	0	4	1
5	7	3	6	9	5	6	4	6	3	8	3	2	2	3	1	1	1		0	9
4	4	3	4	4	4	4	4	5	4	1	4	2	4	4	4	5	4	1	3	3
6	6	4	5	1	4	8	3	9	3	2	2	8	1	4	0	8	0	8	9	7

A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
r	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	0	0	1	1
g.	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
4	4	4	4	5	4	0	4	1	4	2	4	4	4	5	4	1	3	3	3	5
7	5	4	4	2	4			3	1	2	5	1	3	0	8	0	4	9	5	8
4	4	5	4	1	4	1	4	2	4	3	4	5	4	1	3	2	3	5	3	0
8	4	3	4		3	1	2	5	1	8	0	7	0	1	9	9	8	0	8	
4	4	1	4	1	4	2	4	3	4	5	4	9	3	2	3	4	3	5	3	2
9	4		3	0	2	1	1	4	0	0	0		9	4	8	4	8		7	6
5	4	8	4	1	4	3	4	4	4	1	3	2	3	3	3	5	3	1	3	4
0	3		2	8	1	0	0	4	0		9	0	8	7	7	8	7	9	6	1
5	4	1	4	2	4	3	3	5	3	1	3	3	3	4	3	1	3	3	3	5
1	2	4	1	5	0	9	9	4	9	1	8	0	7	9	7	1	6	2	5	5
5	4	2	4	3	3	4	3	3	3	2	3	3	3	4	3	2	3	4	3	9
2	1	0	0	3	9	7	8		8	0	7	9	6	9	6	3	5	5	5	
5	4	2	3	3	3	5	3	1	3	2	3	4	3	1	3	3	3	5	3	2
3	0	5	9	9	8	4	8	1	7	8	6	9	6	0	5	4	4	7	4	2
5	3	2	3	4	3	0	3	1	3	3	3	5	3	2	3	4	3	9	3	3
4	9	9	8	3	8		7	8	6	7	5	8	5	0	4	4	4		3	4
5	3	3	3	4	3	5	3	2	3	4	3	7	3	2	3	5	3	2	3	4
5	3	2	7	7	7		6	4	5	5	5		4	9	3	4	3	0	2	5
5	3	3	3	5	3	1	3	3	3	5	3	1	3	3	3	4	3	3	3	5
6	7	4	6	0	6	0	5	0	4	2	4	5	3	8	3		2	0	1	7
5	3	3	3	5	3	1	3	3	3	5	3	2	3	4	3	1	3	4	3	8
7	6	6	5	2	5	4	4	5	3	7	3	3	2	7	2	3	1	0	1	
5	3	3	3	5	3	1	3	3	3	2	3	2	3	5	3	2	3	4	3	1
8	5	7	4	4	4	7	3	9	3		2	9	1	5	1	1	0	9	0	8
5	3	3	3	5	3	1	3	4	3	7	3	3	3	1	3	2	2	5	2	2
9	4	7	3	6	3	9	2	3	2		1	4	1		0	8	9	7	9	7
6	3	3	3	5	3	2	3	4	3	1	3	3	3	6	2	3	2	5	2	3
0	3	7	2	8	2	1	1	6	1	1	0	8	0		9	5	9		8	5

altitude-arguments 61–90

Column-group headers identical to page 1 (radius-argument 52–61; distances 92028, 93798, 95568, 97337, 99107, 100877, 102647, 104416, 106186, 107956).

A	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
r	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	0	0	1	1
g.	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
6	3	3	3	5	3	2	3	4	3	1	2	4	2	1	2	4	2	1	2	4
1	2	6	1	8	1	2	0	8	0	4	9	2	9	1	8	1	8	2	7	3
6	3	3	3	5	3	2	2	4	2	1	2	4	2	1	2	4	2	1	2	5
2	1	4	0	8	0	3	9	9	9	7	8	6	8	6	7	7	7	9	6	1
6	3	3	2	5	2	2	2	5	2	1	2	4	2	2	2	5	2	2	2	5
3	0	1	9	7	9	3	8	0	8	9	7	9	7	0	6	2	6	5	5	8
6	2	2	2	5	2	2	2	5	2	2	2	5	2	2	2	5	2	3	2	5
4	9	9	8	6	8	3	7	0	7	1	6	2	6	4	5	7	5	1	5	
6	2	2	2	5	2	2	2	5	2	2	2	5	2	2	2	1	2	3	2	1
5	8	6	7	4	7	2	6	0	6	2	5	4	5	7	5		4	6	4	1
6	2	2	2	5	2	2	2	5	2	2	2	5	2	2	2	4	2	4	2	1
6	7	2	6	1	6	1	5	0	5	3	4	6	4	9	4		3	0	3	7
6	2	1	2	4	2	1	2	5	2	2	2	5	2	3	2	7	2	4	2	2
7	6	8	5	8	5	9	4	0	4	3	3	7	3	2	3		2	4	2	2
6	2	1	2	4	2	1	2	4	2	2	2	5	2	3	2	1	2	4	2	2
8	5	3	4	4	4	6	3	9	3	3	2	8	2	4	2	0	1	8	1	7
6	2	8	2	4	2	1	2	4	2	2	2	5	2	3	2	1	2	5	2	3
9	4		3	0	3	3	2	8	2	2	1	9	1	6	1	3	0	2	0	1
7	2	2	2	3	2	1	2	4	2	2	2	5	2	3	2	1	1	5	1	3
0	3		2	5	2	0	1	6	1	1	0	9	0	7	0	5	9	5	9	5
7	2	5	2	3	2	6	2	4	2	2	1	5	1	3	1	1	1	5	1	3
1	2	6	1	0	1		0	3	0	0	9	9	9	8	9	7	8	8	8	9
7	2	4	2	2	2	2	1	4	1	1	1	5	1	3	1	1	1	0	1	4
2	0	9	0	5	0		9	0	9	9	8	9	8	9	8	9	8		7	2
7	1	4	1	1	1	5	1	3	1	1	1	5	1	3	1	2	1	2	1	4
3	9	1	9	9	8	8	8	6	8	8	7	8	7	9	7	0	7		6	5
7	1	3	1	1	1	5	1	3	1	1	1	5	1	3	1	2	1	4	1	4
4	8	2	8	3	7	4	7	2	7	6	6	6	6	8	6	0	6		5	7
7	1	2	1	6	1	4	1	2	1	1	1	5	1	3	1	2	1	5	1	4
5	7	2	7		6	9	6	8	6	4	5	3	5	6	5	0	5		4	9
7	1	1	1	5	1	4	1	2	1	1	1	5	1	3	1	2	1	7	1	5
6	6	5	5	9	5	3	5	4	5	1	4	0	4	5	4	0	4		3	1

[illegible]

USE OF THE TABLE OF PARALLAXES [USUS TABULAE PARALLAXIUM]

When we wish to investigate the Moon's distance from the Earth and its parallax, we must first have ready at hand the Moon's true position as computed from these tables of ours — and above all the eccentricity, the prosthaphaeresis of the eccentricity [prosthaphaeresin eccentricitatis], together with the Moon's anomaly equated a second time [anomaliam secundo coaequata]. For just as the prosthaphaeresis of the eccentricity stands to the eccentricity itself, so does the sine of the anomaly equated a second time stand to the true distance of the Moon from the Earth — in those same parts in which the semidiameter of the eccentric is taken as 100000.

Then, with these distances expressed in whole semidiameters of the Earth, as noted in the upper part of the table, one compares for the degree of altitude the corresponding parallax (applying the proportional correction at both points, if need be, as is otherwise customary). This will easily be understood from the following example.

EXAMPLE AT APOGEE [EXEMPLUM IN APOGEO]

In the year 1597, in the month of March, on the 15th day, at the hour 5h 36m, the Moon was observed as it crossed the meridian. Its altitude was $62^{\circ} 24'$, and its observed latitude $4^{\circ} 48'$ north; but the Moon's true latitude was $5^{\circ} 14' 50''$ north. The difference between this and the observed latitude, $26' 50''$, is therefore the parallax of altitude [parallaxis altitudinis] — which we wish to investigate from the tables as well, in this way.

For the given time, the Moon's mean motions are gathered: in longitude $3s 1^{\circ} 21' 24''$; the anomaly $19^{\circ} 19' 37''$; the latitude $3s 9^{\circ} 30' 58''$. The true position of the Sun is $5s 7^{\circ} 26' 7''$ [recte: $\odot 5s 7^{\circ} 26' 7''$]. The eccentricity is 4345. The prosthaphaeresis of the eccentricity is $47' 52''$. The anomaly equated a second time is $20^{\circ} 1' 27''$. Now, as the sine of the prosthaphaeresis of the eccentricity, 13923[?]⁴, is to the eccentricity itself, 4345, so the sine of the complement of the anomaly equated a second time, 3424209, is to the Moon's distance from the Earth, which will be 1068·57 [106857] in parts of the semidiameter of the eccentric.

Entering the Table of Parallaxes with this value, I compare it with the other distances noted in the upper margin; and having applied the proportional correction, the Moon's parallax of altitude comes out as $26' 47''$.

EXAMPLE AT PERIGEE [EXEMPLUM IN PERIGEO]

In the year 1592, on the 19th day of August, at the hour 18m 8s [recte: hora ..., 18m 8s?], the Moon's parallax was observed in the circle of altitude as 38' 10". We investigate the same value for the given time from the tables in this way.

We inquire first into the Moon's mean motions: in longitude 9s 1° 22' 53"; the anomaly 6s 0° 42' 40"; the latitude 11s 16° 39' 31". The true position of the Sun is 6s 0° 44' 18" M. The eccentricity is 4341. The prosthaphaeresis of the eccentricity is 6° 56' [recte: 6' 56"?]. The anomaly equated a second time is 5s 27° 31' 47". Then it comes about that, as the right sine of the prosthaphaeresis of the eccentricity, 20168, is to the eccentricity itself, 4341, so the sine of the complement of the anomaly equated a second time...

[the sine of the complement of the anomaly] equated a second time, 43102, is to the Moon's distance from the Earth, 92767, which in semidiameters [of the Earth] gives 52° 25' [52.25]. With these semidiameters and the altitude of 54° 16', there is taken from the table the Moon's parallax in the circle of altitude, 38' 55".

From these two examples, then, it is clear that the greatest and least range of the Moon's distance from the Earth does not reach — by observation on both sides, diligently examined — seven of the Earth's semidiameters, a span which is otherwise very rarely granted in such revolutions of the Moon. Let no one therefore be troubled by any scruple that we have confined the limits of the lunar revolutions to within eight semidiameters at most — a far smaller interval than the earlier astronomers allowed — given that the observations do not admit even this much. Rather, since the hypothesis required it (the hypothesis that saves all the other appearances as to longitude and latitude), we did not hesitate to widen this space by roughly two semidiameters.

From this it follows that, even though the Moon was not at its most remote and its nearest distance when the observations were carried out, the discrepancy in distance would be almost imperceptible. Indeed — and this is the more telling point — the two minutes or so [duo circiter minuta] which no one in the Moon's case could fail to find escaping the senses, one may justly say arise from those very semidiameters. I have brought this up so that fair-minded assessors may understand that I have not narrowed these limits too tightly, but rather have, in setting their bounds, made some allowance — for the sake of the visual senses, in case any error or some hallucination should have crept in — for a certain dilatation, insofar as it could be conceded; and that I have not lightly departed from the tradition of the ancients, nor without evident cause.

TABLE OF LUNAR REFRACTIONS [TABULA REFRACTIONUM LUNAE]

G	'	"	G	'	"	G	'	"
0	33	0	15	8	0	30	1	45
1	25	0	16	7	30	31	1	30
2	20	0	17	7	0	32	1	20
3	17	0	18	6	30	33	1	10
4	15	20	19	6	0	34	1	0
5	14	20	20	5	30	35	0	50
6	13	50	21	5	0	36	0	45
7	12	45	22	4	35	37	0	40
8	12	0	23	4	10	38	0	35
9	11	20	24	3	45	39	0	30
10	10	45	25	3	20	40	0	25
11	10	10	26	3	0	41	0	20
12	9	35	27	2	40	42	0	15
13	9	0	28	2	20	43	0	10
14	8	30	29	2	0	44	0	5
15	8	9	30	1	4	45	0	0

ON LUNAR REFRACTIONS [DE REFRACTIONIBUS LUNAE]

Earlier, when treating of the Sun, it was shown that it appears refracted and higher than it really is, especially in a low position, the optical principles requiring this on account of the vapors near the horizon and even the air itself, however pure, lying in the way. Repeated experience has taught us that the same happens in the case of the Moon as well — and with a refraction not at all unlike [that of the Sun] as to its quantity, which in the circle of altitude, gradually thinning out, does not exceed half a quadrant, just as in the Sun's case. We therefore append here the small table of lunar refractions, as far as the visual senses allowed us to admit them, drawn from its own place already set out above for the Sun — differing from it as little as possible.

First Example.

In the year 1566, on the 28th of June, at 11 hours 11 minutes, from the observed meridian altitude the Moon's place was $4^{\circ} 53'$ of Pisces [4 P. 53'], while the true place of the Moon was $4^{\circ} 49'$ of Pisces [4 P. 49'] [Margin/symbol: ♋ — i.e. Pisces]. The observed latitude was $4^{\circ} 44'$ [4 P. 44'], whereas calculation gives $4^{\circ} 58' 20''$ [4 P. 58' 20"]. The difference between these yields the refraction sought, $14' 21''$.

Second Example.

In the year 1587, on the 4th of August, at 9 hours P.M., from the observed meridian altitude of $15^{\circ} 1'$ [15 P. 1'], when the true place of the Moon was $7^{\circ} 31' 40''$ of Pisces [7 P. 31' 40"], the Moon [♃] presented an observed latitude of $5^{\circ} 14' 49''$ [5 P. 14' 49"], whereas the true latitude was $5^{\circ} 6'$ [5 P. 6']. The difference shows the refraction sought, $8' 49''$.

A BRIEF AND CONCISE METHOD OF COMPUTING ECLIPSES, drawn almost entirely from the Solar Tables inserted into this chapter.

1. For finding the times of the mean syzygies in eclipses of the luminaries.

Near the time of an impending eclipse — that is, at the noon of the preceding or following day — take the Moon's simple motion from the Sun [☉]. If it exactly completes a full circle, it indicates a mean conjunction [♌]; but if it completes only a half-circle, it indicates a mean opposition [♍], corresponding precisely to that moment of time. Since, however, this rarely happens exactly, you must consider the excess or deficiency above the full circle or the half-circle, and resolve it logistically into the Moon's simple daily motion relative to the Sun [☉]. Or, more easily: with the stated excess or deficiency, enter the tables of the Moon's simple motion from the Sun given above, and from the side take off the days and hours — adding or subtracting a fraction as the case requires for the time assumed — so that the time of the sought mean syzygy of the luminaries emerges. Once this is found, look up in the appropriate Tables of mean motions, for that same moment, both the Sun's [☉] anomaly and the Moon's [♃] anomaly, together with the Moon's [♃] simple motion in latitude — all of which are reserved for ascertaining the true conjunction [♌] or opposition [♍] in respect of time.

A More Compendious Method.

Once an Epoch has been established in this way, agreeing with a conjunction [♌] or opposition [♍] of the luminaries, the same is easily extended and adapted without trouble to any other nearby eclipses, by means of the following table of synodic revolutions; and the motions are likewise found out at the same time. For if you carefully consider the revolutions elapsed between the Epoch and the present eclipse, you will find alongside them in our Table the days, hours, minutes, and seconds,

— to be added, together with their own appropriate motions, to the Epoch, which likewise, according to the number of days, indicate further the month and day, and so forth, of the mean conjunction [♌] or opposition [♍] sought, as will become clear afterward in the examples.

How the true conjunction [♌] or opposition [♍] of time is to be found, as nearly as possible.

Look up in the tables and work out the prosthaphaereses of both luminaries from the anomalies of the same, previously found as appropriate, according to the rules delivered above — and note carefully what the individual denominations of each may have been. For if they are of opposite kinds, combine them, and you will have the distance between the mean and the true conjunction [♌] or opposition [♍]. Which of them precedes or follows with respect to time, you may know from the Lunar prosthaphaeresis: if it has been subtractive, that is a sign that the time of the mean conjunction [♌] or opposition [♍] has preceded the true; and conversely. But when both prosthaphaereses, of the Sun as well as the Moon, are of the same kind — and since it rarely happens that they are equal — the time of the mean and that of the true conjunction [♌] or opposition [♍] coincide at the same moment. But if they are unequal, and the Moon's [prosthaphaeresis] is the greater and subtractive, or the lesser and additive, the mean syzygy precedes the true; and conversely, if the Sun's prosthaphaeresis is the one so affected. Now resolve the aggregate of the prosthaphaereses in the former case, and the difference of the same in the latter, into the time sought in this way. Multiply 24 hours by the same, and divide the sum by the Moon's daily motion from the Sun, in so far as the lunar anomaly supplies that from the first column of the following table. This quotient, if you have duly adapted it to the time of the mean conjunction [♌] or opposition [♍] previously found, gives the time of the true syzygy of the luminaries in eclipses, as nearly as possible. It is to

be noted here, however, that the interval between the mean and the true time of a single syzygy never exceeds $13\frac{2}{3}$ hours [H. $13\frac{2}{3}$].

Whether the syzygy will be ecliptic.

Furthermore, to know whether the time of the syzygy will be ecliptic — that is, whether some eclipse will or will not occur at the conjunction [☿] or opposition [♄] established in time — proceed thus. Make the Moon's [☾] simple motion in latitude equal, by means of the prosthaphaeresis in longitude previously found, and inquire the Moon's true latitude in a lunar eclipse; but in a solar eclipse, the apparent latitude, taking account of the parallax in latitude ἐν παραλλάξει [Greek: en parallaxei, "in respect of parallax"]. What results, if it is less than the semidiameters of the Moon [☾] and the shadow conjoined in a lunar eclipse [☾ eclipse], or of the Sun [☉] and Moon [☾] in a solar eclipse [☉ eclipse], is then an indication that an eclipse will certainly occur. But we shall test the same more compendiously in a lunar eclipse. Since indeed, once the motion in latitude is made equal, if an eclipse is to occur, it ought to be contained within a distance of $12\frac{3}{4}^\circ$ [$12\frac{3}{4}$ P.] from one or the other of the nodes. But it is better to use the comparison of the latitude itself, together with the measure of the semidiameters in the manner just indicated, to show the indication of an eclipse of either luminary — and most of all of the Sun [☉], on account of the involvement of parallaxes, variable in different climates.

Proof of whether the true conjunction [☿] or opposition [♄] has been rightly established, and how it is to be limited.

The testing of the time of the true syzygies — whether it has been duly set up to the value found, from the preceding [steps], and competently instituted — is carried out if, for the same time arrived at, you investigate afresh the true motion of both luminaries according to our Calculation as delivered above in their places, and that with due precision. For if the prior motion of the Moon does not then agree with this last value found — which easily happens among the many variations not previously taken into account — the difference that arises, compared with the Sun's motion, must be limited in due manner, and converted into time by means of the Moon's hourly motion from the Sun [☉]. And thus you will fashion the time of the true conjunction [☿] or opposition [♄] more subtly corrected, as appears through the little Table of the Moon's equation (on account of the annual involvement), readily convertible with no trouble.

A Method for elucidating the parallaxes of the luminaries in a solar eclipse.

The Sun's [☉] distance from the horizon in the vertical circle, agreeing with the given time of the true conjunction [♌], will be established easily at any elevation of the pole, by the doctrine of the *primum mobile*, or rather by the resolution of a single spherical triangle. For since the Sun's [☉] declination, together with its distance from the meridian, is known by the benefit of the known time, these are readily at hand. For in a spherical triangle there are given two sides — one from the complement of the pole's altitude, the other from the complement of the Sun's [☉] declination — together with the angle they contain, which is measured by the Sun's [☉] distance from the meridian in degrees of the equator, to be elicited from the measure of the antemeridian or postmeridian time in the customary manner. And so, by the reasonings of triangles, the third side will be established, namely the complement of the Sun's altitude above the horizon, exhibiting the Sun [☉] in the circle of altitude from its own proper Table; and likewise the Moon's [☾] parallaxes according to its appropriate distance from the Earth, the proportional part being applied where there is need. From the Moon's parallax subtract the parallax of the Sun, and there will remain the sole parallax of the Moon from the Sun [☉] in the circle of altitude. But how this is then more conveniently distributed in longitude and latitude, and afterward duly applied to the Moon's true motion, so that the apparent [place] emerges, we shall carry out in the following example by the demonstration of a solar eclipse, with a brief indication of how that *Pragmatia* [practical procedure] of ours may be rightly adapted to any other cases whatever. Now we shall append the tables serving the aforesaid business of eclipses. Afterward we shall give examples, illustrating the whole matter, otherwise perhaps somewhat obscure to some — and that in two eclipses, which will occur in this present year.

TABLE OF THE HOURLY MOTION OF THE MOON in conjunction [♌] and opposition [♏], and likewise of the half-day before and after.

The table is arranged in two stacked halves. Each half has twelve sub-columns grouped under six argument-headings (numbered blocks). Each numbered block carries two sub-columns: "**Horari: in ♌ & ♏**" (hourly [motion] in conjunction & opposition) and "**Horari: ultra**" (hourly [motion] beyond), each subdivided into **M** (minutes) and **S** (seconds). The leftmost and rightmost vertical strips give the argument "**Ano: ☾ coæ**" (anomaly of the Moon, made equal), running 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30 downward on the left (ascending) and 30, 27, 24, ..., 0

downward on the right (descending), with "quarta Ano: 》 coæ" (the fourth-quadrant anomaly) labels at the band breaks.

Upper half — blocks 0, 1, 2 (top edge) / 11, 10, 9 (bottom edge of upper half):

Ano 》 (L)	0: inσσ M	0: ultra M	1: inσσ M	1: ultra M	2: inσσ M	2: ultra M	Ano 》 (R)
0	27	27	28	27	29	28	30
3	27	27	28	27	29	28	27
6	27	27	28	27	29	29	24
9	27	27	28	27	29	29	21
12	27	27	28	27	29	29	18
15	27	27	28	28	29	29	15
18	27	27	28	28	29	29	12
21	27	27	28	28	29	30	9
24	27	27	28	28	30	30	6
27	28	27	28	28	30	30	3
30	28	27	29	28	30	30	0

(Lower-edge block labels for this upper half, read right→left: **11, 10, 9**; the right-margin argument runs 30→0 descending.)

Lower half — blocks 3, 4, 5 (top edge of lower half) / 8, 7, 6 (bottom edge):

Ano 》 (L)	3: inσσ M	3: ultra M	4: inσσ M	4: ultra M	5: inσσ M	5: ultra M	S	Ano 》 (R)
0	30	30	31	32	32	34	45	0
3	30	30	31	33	33	34	53	30
6	30	31	32	33	33	35	0	27
9	30	31	32	33	33	35	8	24
12	30	31	32	33	33	35	[nume ral: ?]4	21
15	31	31	32	33	33	35	18	18
18	31	32	32	34	33	35	24	15
21	31	32	32	34	33	35	29	12

Ano » (L)	3: inꝛꝛ M	3: ultra M	4: inꝛꝛ M	4: ultra M	5: inꝛꝛ M	5: ultra M	S	Ano » (R)
24	31	32	32	34	33	35	32	9
27	31	32	32	54	33	35	24	6
30	31	32	32	34	33	35	37	2

(Lower-edge block labels for this lower half, read right→left: **8, 7, 6**; the bottom-right argument value reads **2** rather than the expected 0 — transcribed as printed and flagged.)

Table of the Synodic Revolution of the Moon with Respect to the Sun [Tabula Synodicae Revolutionis Lunae ad Solem]

The table has, beneath a top band of grouped headings, a "Month" [Men.] row-label column followed by paired Common-year / Leap-year columns, and then four major field-groups: the Time of conjunction [Tempus ꝛ], the Anomaly of the Sun [Anom. ☉], the Anomaly of the Moon [Anom. »], and the Latitude of the Moon [Latit. »]. Each field is subdivided into columns labeled with the standard sexagesimal/temporal units. For the Time of conjunction these are **D H M S** (Days, Hours, Minutes, Seconds); for each of the three angular fields they are **S G M S** (Signs, Degrees [Gradus], Minutes, Seconds). The leftmost numeric pair under the month names is headed **Co.** (Common year [Communis]) and **Biss.** (Leap year [Bissextilis]).

Men.	Co																	
	.	Biss.	D	H	M	S	S	G	M	S	S	G	M	S	S	G	M	S
Ianu.	31	31	29	1	4	3	0	2	6	2	0	2	4	0	1	0	4	1
				2	4			9		1		5	9				0	4
Febr.	59	60	59	1	2	6	1	2	1	4	1	2	3	0	2	1	2	2
					8			8	2	1		1	8				0	8
Mar.	90	91	88	1	1	9	2	2	1	2	2	1	2	1	3	2	0	4
				4	2			7	9			7	7					2
Apri.	12	121	11	2	5	1	3	2	2	2	3	1	1	1	4	2	4	5
	0		8		6	3		6	5	3		3	6				0	6
Mai.	15	152	14	1	4	1	4	2	3	4	4	9	5	1	5	3	2	9
	1		7	5	0	6		5	1	3							1	
Iuni.	18	182	17	4	2	1	5	2	3	4	5	4	5	1	6	4	1	2

Men.	Co	Biss.	D	H	M	S	S	G	M	S	S	G	M	S	S	G	M	S
	1		7		4	9		4	8				4					3
Iuli.	21	213	20	1	8	2	6	2	4	2	6	0	4	1	7	4	4	3
	2		6	7		2		3	4	5			3				1	7
Aug.	24	244	23	5	5	2	7	2	5	4	6	2	3	2	8	5	2	5
	3		6		2	5		2	0	5		6	2				1	1
Sept.	27	274	26	1	3	2	8	2	5	6	7	2	2	2	9	6	2	5
	3		5	8	6	8		1	7			2	1					
Octo.	30	305	29	7	2	3	9	2	3	2	8	1	1	2	1	6	4	1
	4		5		0	1		1		7		8	0		0		2	9
Nove.	33	335	32	2	4	3	1	2	9	4	9	1	5	2	1	7	2	3
	4		4	0		5	0	0		7		3	9		1		2	3
Dece.	36	366	35	8	4	3	1	1	1	8	1	9	4	2	0	8	2	7
	5		4		8	8	1	9	6		0		8					4
Dim. Mensis			14	1	2	2	0	1	3	1	6	1	5	3	6	1	2	7
				8	2			4	3	1		2	4	0		5	0	

FIRST EXAMPLE, IN A LUNAR ECLIPSE [PRIMUM EXEMPLUM IN ECLIPSI LUNAE]

In the year 1601, in the month of November, an eclyptic full Moon [Plenilunium Eclypticum] is to occur. The mean motion of the Moon from the Sun, at the meridian of 1 November, is 6 signs 15 degrees 16' 28". There are therefore lacking, to complete the whole circle, 5 signs 14 degrees 43' 32"; and when this remainder is divided by the daily motion of the Moon from the Sun — or, more precisely, entered into the table of longitude — it yields the time of the mean opposition [media $\odot$, *mediae oppositionis*] on the 28th day, completed at 6 hours 39' 49".

Or [Vel]

At the meridian of 1 January of the current year 1601, the mean motion of the Moon from the Sun is 12 signs 29 degrees 17' 13"; the remainder to the whole circle is 9 signs 0 degrees 42' 47", which, divided into the Moon's daily motion, gives 22 days 4 hours 57'. Let this be the radix [Radix] of the opposition for the present year. Then enter the table of the Moon's synodic revolution, and to the numbers assigned to the completed month of October — 295 days, 7 hours 20' 31" — add the radix of the conjunction set down above; and the result will be — after

casting off the 304 days elapsed from the beginning of the transacted year — 13 days 12 hours 17' 49". To this let the half-month be added, 4 days 18 hours 22' 2", and the time of the mean opposition will come out as 28 days 6 hours 39' 51", differing from the earlier figure by at most two seconds.

For this time, then — 28 days 6 hours 39' 49" — let the mean motions be sought, and they will be found to be of this kind:

- Apogee of the Sun [Apog. ☉]: 3 signs 5 degrees 40' 26".
- Mean Sun [Solis simpl., *Solis simplex*]: 8 signs 18 degrees 25' 42".
- Longitude of the Moon from the Sun [Long. ☾ à ☉]: 6 signs 0 degrees 0' 0".
- Anomaly of the Moon [Anom. ☾]: 5 signs 21 degrees 41' 42".
- Latitude of the Moon [Latit. ☾]: 5 signs 24 degrees 36' 7".
- Equation of the Sun [Prostap. ☉, *prosthaphaeresis*]: 37' 50", to be subtracted [Subt.].
- Equation of the Moon [Prosthaph. ☾]: 14' 48", also to be subtracted [Subt.].

And since these

equations [prosthaphaereses] are of the same kind, their difference, 6' 58", shows the arc of precession [arcum praecessionis] by which one luminary anticipates the other. But since the lunar equation is greater than the solar, the true opposition follows the mean one. To learn by how great an interval of time this happens, the Moon's hourly motion from the Sun, drawn from its own table by the Moon's distance from the apogee, is 35' 29". If, then, we divide the arc of precession by this, the interval will come out as 11' 30". Add this; and so the time of the true opposition will be 6 hours 51 minutes 19'. For this time the mean motions are found to be: Sun [Sol] 8 signs 18 degrees 26' 10"; Longitude of the Moon [Long. ☾] 6 signs 0 degrees 5' 50"; Anomaly of the Moon [Anom. Lunae] 5 signs 21 degrees 47' 27"; Latitude [Latit.] 5 signs 24 degrees 42' 27"; the true place of the Sun [Verus locus Solis] 17 degrees 48' 22"; the place of the Moon [Locus Lunae] 17 degrees 48' 1". The difference is 21", which, divided into the Moon's hourly motion of 35' 29", gives 36" to be added to the time of the true opposition — because the Moon's place still precedes — and so the time, exactly determined, will be 6 hours 51' 55". The true place of the Sun is then 17 degrees 48' 23"; that of the Moon ✎ [Sagittarius] 17 degrees 48' 23". II.

FOR THE TRUE LATITUDE OF THE MOON [PRO LATITUDINE LUNAE VERA]

The mean motion of latitude appropriate to the determined time of true opposition is 5 signs 24 degrees 42' 47". From this let the absolute equation of the Moon, 43' 57", be taken away, and the true motion of latitude remains: 5 signs 23 degrees 58' 50". To this the table gives the corresponding true latitude of the Moon, 31' 16" North [Bor., *Borealis*]. Nor is there here any need for long detours, as elsewhere, since at a full Moon the equation of the nodes [Prosthaphaeresis Noderum] introduces no difference at all.

FOR THE ECLIPTIC DIGITS AND THE SCRUPLES OF INCIDENCE [PRO DIGITIS ECLYPTICIS ET SCRUPULIS INCIDENTIAE]

When the anomaly of the Moon, first equated to 5 signs 21 degrees 3' 50", is taken, there are drawn from the table of semidiameters: the semidiameter of the Moon, 17' 58"; that of the shadow [Umbrae], 46' 56". But to the anomaly of the Sun corresponds a variation of the shadow [Variatio umbrae] to be subtracted, 56". The determined semidiameter of the shadow will therefore be 46' 0". The sum of both semidiameters — of the Moon and of the shadow — comes to 63' 58"; from this let the Moon's latitude, 31' 16", be subtracted, and the residue will be 32' 42". This, multiplied by 12 digits and divided by the whole diameter of the Moon, shows the ecliptic digits [digitos eclypticos]: 10 digits 55' 6".

The scruples of incidence [Scrupula incidentiae] are disclosed thus. Let the sum of the semidiameters of the Moon and of the shadow, 63' 58", be resolved into seconds, and squared; the square comes out as 14730244. In the same way let the Moon's latitude, 35' 19" [recte: 31' 16"?], be squared: 3519376. Let this be subtracted from the square of the semidiameters, and there will remain the square of the scruples of incidence; which, divided by the Moon's hourly motion, will give the time of incidence: 1 hour 47' 50".

ON THE REDUCTION OF EQUAL TIME TO APPARENT TIME, AND TO THE MERIDIAN OF PRAGUE [DE REDUCTIONE TEMPORIS AEQUALIS IN APPARENS, & AD MERIDIANUM PRAGENSEM]

In order that the apparent time may be established as the time of the eclipse stands fixed, the equation of time [aequatio Temporis] from the place of the Sun, entered into the table of the Moon's equation, comes out as 4' 2", to be added. The reduction to the meridian of Prague, which we assume to be 35 degrees, adds 5 minutes. So that the True Time of the mean Eclipse, equated and reduced to Prague in Bohemia — or to some other comparable meridian — is, after midday, of the 29th day, 7 hours 0' 57".

ON THE TIME OF BEGINNING AND END OF THE ECLIPSE, AND ITS WHOLE DURATION [DE TEMPORE INITII ET FINIS ECLYPSIS & TOTA DURATIONE]

From that mean time so found, let the time of incidence previously discovered be subtracted, and the beginning will appear: 5 hours 13' 7". But if the same is added to the mean, the end will come out: 8 hours 48' 47". And when these two are combined, the whole duration is revealed: 3 hours 35' 40".

FOR THE DIAGRAM OF THE LUNAR ECLIPSE [PRO TYPO ECLYPSIS LUNAE]

The true motion of the Sun corresponding to the time of incidence is 4' 35"; this, added to the scruples of incidence, gives the motion of latitude congruent to half the duration: 1 degree 0' 23". This is subtracted from, and added to, the true motion of latitude at the time of true opposition, 5 signs 23 degrees 58' 50"; and the true motion of latitude at the beginning of the eclipse will come out as 5 signs 22 degrees 58' 27", to which corresponds a latitude of the Moon of 36' 27" North. And the true motion of latitude at the end is 5 signs 24 degrees 59' 13". There belongs to it a latitude of the Moon of 26' 2" North.

Now let a certain line A B be divided into 70 parts, and on it let there be taken the minutes of the sum of the semidiameters of the shadow and of the Moon; and from center C let the circle C E be described. Let the same be done with the semidiameter of the shadow, and let the circle C D be drawn; let the transverse diameter I C E also be drawn. At the interval of the true latitude of the Moon at

the beginning of the eclipse, let a line parallel to I E be drawn; this cuts the outer circle at F. Then let the latitude of the Moon at the end be counted off toward I, and let a parallel to I E be drawn, which will cross the same outer circle at G. Let G and F be joined by a straight line, which is bisected at H; and through I, H, G let three lunar circles be described, drawn at the quantity of its semidiameter; and so the true representation of this eclipse will be set forth.

Diagram. A geometric construction of the lunar eclipse. A large outer circle (the penumbra/path circle centered on C) contains a shaded inner disk representing the Earth's shadow [Umbra]; a smaller hatched disk near the top represents the Moon at mid-eclipse, overlapping the shadow. Two small circles labeled G (upper left) and F (upper right) sit on the shadow's circumference, marking the Moon's positions at the beginning and end of the eclipse; a horizontal diameter runs through I (left), C (center), D, and E (right). A graduated scale-bar appears below the figure.

- C (center): center of the shadow circle.
- I (left end of horizontal diameter): the western point of the construction line I C E.
- D (on horizontal axis, right of center): endpoint of the shadow-semidiameter circle C D.
- E (right end of horizontal diameter): endpoint of the larger circle C E.
- F (upper right small circle): position of the Moon at one terminus (end) of the eclipse.
- G (upper left small circle): position of the Moon at the other terminus (beginning) of the eclipse.
- (Top hatched disk, between G and F): the Moon at mid-eclipse, overlapping the shaded shadow.
- Scale-bar (below figure): graduated, reading right-to-left "70 | 60 | 50 | 40 | 30 | 20 | 10".

SECOND EXAMPLE, IN A SOLAR ECLIPSE, WHICH WILL OCCUR IN THE YEAR 1601, ON THE 14TH DAY OF DECEMBER [ALTERUM EXEMPLUM IN ECLIPSI SOLARI, QUAE CONTINGET ANNO 1601. DIE 14. DEC.]

- Epoch of the longitude of the Moon from the Sun [Epocha Long. ☾ à ☉] at the beginning of December: 6 signs 20 degrees 27' 17".
- Complement to the whole circle: 5 signs 9 degrees 2' 43".

This, divided into the daily motion of the Moon from the Sun, gives the time of the mean conjunction [mediae ☿] on the 13th day of December completed, at the hour of 1, 6 minutes 47" P.M. at Prague.

For this time the equal motions are gathered together:

- Anomaly of the Sun [Anomalía ☉]: 5 signs 27 degrees 18' 27".
Corresponding solar equation [Resp. Prosthaph. ☉]: 0 degrees 6' 1", to be subtracted [sub.].
- Anomaly of the Moon [Anomalía ♀]: 0 signs 5 degrees 4 [P.] 36' 11" [?].
Corresponding lunar equation [Resp. Prosth. ♀]: 0 degrees 23' 1", to be subtracted [sub.].

And since the equation of the Moon is greater than that of the Sun, and is subtractive, the mean conjunction precedes the true. The difference of the equations, 17', divided into the Moon's hourly motion, which is 27' 12", shows an interval of time of 37 minutes 30". Add this, so that the time of the true conjunction may come out as 1 hour 44 minutes 17" P.M.; and, when the limitation has been made by repeating the equations, 1 hour 44' 22". For this time the equal motions are taken: mean Sun [☉ simpl.] 9 signs 3 degrees 0' 27"; apogee [Apog.] 3 signs 5 degrees 40' 28"; whence the true place of the Sun [verus locus ☉] is 2 degrees 54' 30" ♍ [Capricorn]. The simple motion of the Moon from the Sun [Motus ♀ simplex à ☿] is 0 signs 0 degrees 19' 5" [?]. The simple anomaly of the Moon [Anom. ♀ simplex] is 4 degrees 56' 38"; the true place of the Moon [verus locus ♀] is 2 degrees 54' 29" ♍. And so the difference is by one scruple of second only — imperceptible.

Next, for the altitude of the Sun above the horizon at this time, in the assigned diagram: let E B S be the meridian; E C S the horizon; D T C the zodiac, in which the Sun is at T. Let the vertical circle through T be B T H. Let the circle of declination from the pole of the world A through the Sun be A T. Now in the spherical oblique-angled triangle B A T are given: the side B A, the complement of the elevation of the pole of Prague, 39 degrees 54' 15"; and A T, 113 degrees 29' 34", which is constituted from the quadrant and the declination of the Sun, 23 degrees 29' 34", together with the angle B A T intercepted, which measures the time elapsed after midday, 25 degrees 49' 45". There becomes known therefore the side B T, 77 degrees 4' 13", the complement of the altitude of the Sun above the horizon; and so the altitude itself is 12 degrees 55' 47".

The right ascension of the true place of the Sun [Ascensio Recta veri loci ☉] is 273 degrees 10' 18". To this are added the degrees corresponding to the time elapsed

after midday, 25 degrees 49' 45", and the right ascension of the mid-heaven [ascensio Recta M.C., *medii coeli*] rises to 299 degrees 0' 3"; which, diminished by a quadrant, leaves the oblique descension of the horoscope [Descensionem obliquam Horoscopi], to which corresponds the descending degree 26 degrees 9' 48" ♍ [Scorpio]. All of which contribute to the investigation of the parallaxes.

Diagram. A spherical-astronomy diagram for the solar-eclipse parallax computation. A large circle represents the sphere, with several great circles inscribed: the meridian E B S, the horizon E C S, and the zodiac D T C, intersecting at the Sun's position T near the center. Vertical and declination circles pass through T.

- A (upper left): the pole of the world [polo mundi].
- B (top): zenith point / pole of the horizon on the meridian.
- D (upper right): point on the zodiac circle.
- E (right): eastern point (horizon/meridian intersection).
- S (left): point on the meridian/horizon.
- C (lower center-left): point on the horizon E C S.
- T (center): the Sun's place on the zodiac.
- H (lower center): foot of the vertical circle B T H on the horizon.

DE PARALLAXIBUS ENUCLEANDIS. [On the Resolution of the Parallaxes]

Subtract the point of the ecliptic descending from the true place of the Sun ☉, and there will remain — as in the earlier figure — the side T C, 36° 44' 42", in triangle T H C, right-angled at H. Now since in this triangle the side subtending the right angle is given, together with the altitude T H, 12° 55' 47", the angle H T C becomes known by the principles of triangles; and this angle — namely the vertical angle B H — was established at the place already cited as 72° 5' 30". With this angle found, the Sun's parallax ☉ is to be sought in the circle of altitude from our table of parallaxes, Chapter 1, folio 80, which is 3' 2".

For finding parallax a: the Moon's °C distance is to be taken in every opposition ♀ and conjunction ♂ from the side of the Moon's Elongation °C from the centre, which is already 102891 — there comes the distance from the Earth, which is resolved, as above where we treated of parallax (it was there said, in semidiameters), and the Moon's °C distance from the Earth comes out as 58 semidiameters 8'. With this, our table of parallax gives, applying the correction by

the proportional part — the parallax of the Moon $\odot$ at the like altitude that the Sun $\odot$ has (for indeed the difference which the Moon supplies has nothing of significance) in the Circle of Altitude — there is found $57' 52''$. From this is subtracted the parallax of the Sun $\odot$, and there will result the parallax of altitude of the Moon $\odot$ in respect of the Sun, $54' 50''$.

But to resolve this parallax into longitude and latitude, let there be conceived, in this second diagram, the meridian R I H, the ecliptic I K P whose pole is G, and let a certain vertical circle be understood as H Q, in which the Moon $\odot$ lies at K. The parallax of the Moon $\odot$ in respect of the Sun $\odot$ lies in the same vertical circle, namely K M. And from G, the pole of the ecliptic, let two great circles descend through the points K and M.

Diagram. A circular diagram representing the celestial sphere for resolving the Moon's parallax into components of longitude and latitude. The outer circle is the meridian; arcs of the ecliptic and a vertical circle cross within it, and two great circles drawn from the pole of the ecliptic G frame a small right triangle K M O at the position of the Moon.

- H (top): upper point of the meridian / vertical circle
- G (upper left interior): pole of the ecliptic
- I (right of centre, upper): point on the ecliptic / meridian
- K (centre): position of the Moon $\odot$
- M (just below K): foot of the parallax along the vertical circle
- O (left of K): vertex of the small right triangle K M O
- P (lower left): point on the ecliptic
- R (right): point of the meridian
- Q (bottom): lower point of the vertical circle / meridian

Through the points K and M they form the small right triangle K G M, right-angled at O. In this triangle, besides the right angle, the angle M K O is noted, made by the vertical circle and the ecliptic; and in the preceding diagram it was found that H T C is $72^\circ 5' 30''$. Together with one side K M, the Moon's $\odot$ altitude-parallax in respect of the Sun $\odot$, the remaining 2 sides enclosing the right angle become known: K O, which yields the longitude-parallax of the Moon $\odot$ in respect of the Sun $\odot$, $16' 52''$; and M O, the latitude-parallax, which in this practical case has as yet no use.

The longitude-parallax is next to be divided into the true hourly motion of the Moon and Sun $\odot$, which is — as the table makes plain — $27' 12''$, and there will come the assumed interval between the true and the visible conjunction $\odot$, $37'$

12". When this is added to the time of the true conjunction ϕ — since these operations are carried out in the western quadrant of the ecliptic — there leaps forth the estimated time of the visible conjunction ϕ , 2h 24' 22" PM.

For this time, by the very same procedure, let the parallax of each luminary be sought, as was done before. For in the first diagram the angle B A T is given, $35^{\circ} 7' 45''$, together with the sides B A (the complement of the elevation of the pole) and A T (the declination of the Sun $\odot$). The side B T therefore becomes known, whose complement T H is the altitude of the Sun $\odot$ above the horizon, $10^{\circ} 5' 30''$. To the oblique descension of the horoscope there answers the descending degree $8^{\circ} 29' 45''$ Scorpio $\mathbb{M}$, which, taken away from the true place of the Sun $\odot$, leaves the side C T, $24^{\circ} 26' 20''$. From this side, and the altitude H T, the vertical angle of the ecliptic, $66^{\circ} 56' 21''$, is investigated in the right triangle H T C. The parallax of the Sun $\odot$ in the Circle of Altitude comes out as $3' 4''$ (but of the Moon $\mathbb{D}$, $58' 24''$). When the Sun's $\odot$ parallax is subducted from this, the residual parallax is the sole

parallax of the Moon $\mathbb{D}$ in respect of the Sun $\odot$ in the vertical, $55' 20''$. Then, in the other diagram, from the side K M and the angle M K O, $66^{\circ} 56' 21''$, the longitude-parallax of the Moon $\mathbb{D}$ in respect of the Sun $\odot$ is found, $21' 41''$, which exceeds the value previously found by $4' 49''$. This difference, deducted from the true hourly motion $\odot \mathbb{D}$ — namely $16' 52''$ — leaves the visible motion of the Moon $\mathbb{D}$ in the time fixed at $12' 3''$. By this let the longitude-parallax be divided into the true conjunction ϕ once obtained, and there will come the interval $52' 4''$. To this must be added the time of the visible conjunction ϕ , 2h 36' 26" PM. The mean motions answering to the time-interval, added to the prior values at the true conjunction $\odot$ time, constitute the Sun $\odot$, simply, $9^{\circ} 3'$ Capricorn $\mathbb{V}$ in longitude. Anomaly of the Sun $\odot$ $5s 24' 38''$. To these answers the true place of the Sun $\odot$ $2^{\circ} 56' 43''$ Capricorn $\mathbb{V}$; the true place of the Moon $\mathbb{D}$ $3^{\circ} 20' 7''$ Capricorn $\mathbb{V}$. So that the difference of the luminaries is $22' 24''$. To this end therefore, by the very same method posited, the longitude-parallax of the Moon $\mathbb{D}$ in respect of the Sun $\odot$ is to be inquired a third time, as was done before, and it will be found to be $23' 42''$, distant from the difference of the luminaries $18'$; from which we play out the visible time, found with certainty. If, however, anyone should be pleased to chasten this small discrepancy still more exactly, let it be done so.

It is to be considered how far in the preceding examination the visible time is changed by the diversity of parallax, and in proportion to that, those $18''$ are to be remedied by 18 seconds; so that as the difference of the parallaxes in the prior determination, $4' 49''$, produces in the difference of time $12' 3''$, therefore $18''$ are

caused in the discrimination of the parallaxes by 55" of time. This, added to the prior time of the visible conjunction ϕ , brings about most accurately the corrected time 2h 37' 21". And this is the reason that, in eclipses, this method of inquiring the parallaxes by triangles, even if it is somewhat more laborious than that which is commonly used in the Prutenic Tables [tabulae Prutenicae] or others, is nevertheless not less ingenious, and is more fundamental and far more certain. But the latitude-parallax in the same triangle K M O is M O, 50' 13".

Inquisitio visae Latitudinis $\rightarrow$ ad Tempus apparentis Synodi. [Investigation of the Visible Latitude of the Moon at the Time of the Apparent Conjunction]

The mean motion of the Moon's $\rightarrow$ latitude at the visible conjunction ϕ is 10° 46' 10", from which is removed the absolute prosthaphaeresis of the Moon $\rightarrow$ [prosthaphaeresis $\rightarrow$] 27' 51", and there will remain the true 10° 18' 19". The prosthaphaeresis of the Nodes [prosthaphaeresis Nodorum], which is 1' 30", let it be added, and there leaps forth the equated motion of the Moon's latitude $\rightarrow$ 0s 10° 19' 49". With which, from the table of latitudes, I draw out the latitude 53' 28" South; from which the latitude-parallax of the Moon $\rightarrow$ in respect of the Sun $\odot$, 50' 13" — which was found before — being subtracted, leaves the visible latitude 3' 15" South, and this with respect to both, since the parallax, of the Sun $\odot$ as well as the Moon $\rightarrow$ (namely from the visible ecliptic), is regarded.

Pro Semidiametris Luminarium. [For the Semidiameters of the Luminaries]

Since it has been observed that, in eclipses of the luminaries on the ecliptic, the Moon does not keep the same visible diameter that it has at other times, but that by the force of the Sun's $\odot$ light its margins are attenuated — some optical reason suggesting this, to the degree that about a fifth part of the Moon $\rightarrow$ falls away, nor does it offer itself to the sight — for that reason we have judged it necessary to vary somewhat the apparent diameter of the Moon $\rightarrow$ in the eclipses of the luminaries on the ecliptic, just as the Table itself, deputed to this office, shows this distinction.

Therefore, when with the anomaly of the Sun $\odot$ I enter the said table of semidiameters, I find both the semidiameter of the Sun $\odot$ 16' 0", and likewise — answering to the anomaly first equated — the new semidiameter of the Moon $\rightarrow$ 12' 48". The aggregate from the semidiameters of the Sun $\odot$ and the Moon $\rightarrow$ is 28' 48", from which let the visible latitude of the Moon $\rightarrow$ be taken away, and the

residue will be 25' 33". Now by proportion, as the whole diameter of the Sun ☉ 32' 0" stands to 12 digits, so the residue to the eclipse-digits. The operation being performed, the eclipse-digits come out as 9.34' 52".

TABULA SEMIDIAMETRORUM. [Table of the Semidiameters]

Año ☉ et / Anom °C — Sig	SOL IS — M	☾ plena — M	in ☉ — M	S	Umb rae — m	Vari a. — S	Anom ☉ ☉ °C — Sig	G r a .
0	15	16	12	48	43	0	12	0
0	15	16	12	48	43	0	11	2 4
0	15	16	12	49	43	1	11	1 8
0	15	16	12	50½	43	2	11	1 2
0	15	16	12	52	43	3	11	6
0	15	16	12	54½	43	4	11	0
1	15	16	12	58	43	6	10	2 4
1	15	16	13	1	43	9	10	1 8
1	15	16	13	5	[nu mer al: ?]	12	10	1 2
1	15	16	13	8	43	15	10	6
2	15	16	13	12	43	18	10	0
2	15	16	13	17	43	21	9	2 4
2	15	16	13	22	44	24	9	1 8
2	15	16	13	26	44	27	9	1 2
2	15	16	13	31	44	30	9	6
3	15	17	13	25	44	34	9	0

Año ☉ et / Anom °C — Sig	SOL IS — M	☾ plena — M	in ☿ — M	S	Umb rae — m	Vari a. — S	Anom ☉ ☿ °C — Sig	G r a .
				[recte: 35?]				
3	15	17	13	41	44	37	8	2 4
3	15	17	13	46	45	40	8	1 8
3	15	17	13	50	45	43	8	1 2
3	15	17	13	54	45	46	8	6
4	15	17	13	57	45	49	8	0
4	15	17	14	1	45	51	7	2 4
4	15	17	14	5	46	52	7	1 8
4	15	17	14	9	46	53	7	1 2
4	15	17	14	13	46	54	7	6
5	15	17	14	16	46	55	7	0
5	15	17	14	19	46	55	6	2 4
5	15	17	14	22	46	55	6	1 8
5	15	17	14	22	46	56	6	1 2
5	15	17	14	23	46	56	6	6
6	16	18	14	24	47	56	6	0

Pro scrupulis incidentiae. [For the Scruples of Immersion]

Multiply the sum of the semidiameters of the Sun ☉ and the Moon ☾, resolved into seconds, into itself squared, and you will have the square of the

semidiameters. The latitude of the Moon ☾, resolved into seconds and drawn into itself, is subtracted from the square of the semidiameters, and there remains the square of the scruples of immersion, whose root shows the scruples of immersion, 28' 33". And since the visible motion of the Moon ☾ in respect of the Sun ☉ before the visible conjunction ☌ was, as was said, in the assumed minutes 37' 12", it will be 12' 3"; and the Moon ☾ will traverse apparently scruples of this kind in 1 hour 29' 23" — which is the time of immersion.

But in order to have the time of emersion, let it be sought for one hour after the visible conjunction ☌. The longitude-parallax is found 30' 34", which falls short of the visible conjunction ☌ by 6' 52"; this, subtracted from the true hourly motion 27' 12", leaves the visible hourly motion of the Moon ☾ in one hour after the visible conjunction ☌ as 20' 20". By this I divide the scruples of immersion, and there stands the time of emersion, 1h 24' 15". The time of immersion, subtracted from the time of the visible conjunction ☌, brings forth the beginning of the eclipse, 1h 7' 54". But if the time of emersion be added, the end arises, 4h 0' 32". So that the total duration, namely the sum of these two times, is 2h 52' 46".

PRO VISA LATITUDINE LUNAE AD INITIUM ET FINEM ECLIPSIS. [For the Visible Latitude of the Moon at the Beginning and End of the Eclipse]

Since the visible latitude of the Moon ☾ at mid-eclipse falls within the Table of the Moon's Latitude — as they call it elsewhere — take out the latitude-motion answering at that point; subtract from it, and add to it, the scruples of immersion, and you will have the visible motion of the latitude of the Moon ☾ at the beginning and end of the eclipse. To the beginning there answers the latitude of the Moon ☾ 41' South; to the end 5' 1" 39" South. [recte: the printed value "5 / 1 / 39" — likely a misprint for the end-latitude]

PRO TYPO ECLIPSEOS. [For the Diagram of the Eclipse]

In the assigned diagram, let the line A B be divided in the ratio of the two semidiameters of the Sun ☉ and the Moon ☾; let there be taken in it 28' 49", the aggregate of the semidiameters, and with such an interval let a circle be described from the centre C. Let the diameter L C D be drawn. And from the same centre C, with the magnitude of the solar semidiameter, let the circle C M be delineated, representing the solar body. Then, with the interval of the Moon's ☾ latitude at the beginning of the eclipse, let the line I E be drawn parallel to L C D; likewise, with the interval of the Moon's ☾ latitude at the end of the eclipse, let

the line F K be drawn to the same L C D parallel. Connect F E; and the line F E, which will represent the path, let it be bisected at G; and let the straight line C G H be drawn orthogonally. And from the centre G, if you also wish, or from E and F at the interval of the Moon's $\gg$ semidiameter, let three lunar circles be described, of which the two outermost touch the solar one precisely; and the Diagram [Typus] will be complete.

Diagram. A diagram of the solar eclipse (the *Typus*). A large outer circle (the lunar path-circle, centre C) contains a heavily hatched/shaded inner disc representing the solar body, partly overlapped by lighter circles representing the Moon at successive positions. Construction lines cross the figure horizontally and vertically.

- H (top): upper end of the vertical line C G H
- C (centre): centre of the construction
- F (left of centre): point on the path / parallel line F K
- L (lower left): left end of the horizontal diameter L C D
- E (right of centre): point on the path / parallel line I E
- D (right): right end of the horizontal diameter L C D
- M (bottom): lower point of the figure / solar-body circle C M

So much concerning the course of the lunar motion, set out otherwise than our predecessors supposed, and the eclipses of the luminaries reckoned at this place more accurately than before — it suffices to have shown these things by a method ready, brief, and concise. If in future anything touching this work [Progymnasmata] should require some further limitation — which, however, will scarcely be of any moment — that very thing, more fully in its own place and time (God, the heavenly Workman, favouring), I have in mind to resolve and lay open, and not to omit even fuller tables of the eclipses where they shall be of service, all of which I shall furnish in due readiness and abundance. Meanwhile, with this little treatise on the lunar motion, joined to the place of the solar Apogee, let the kindly reader be content, and enjoy it.

CHAPTER TWO

On the fixed stars [Stellae Inerrantes] — how their positions, made to agree exactly with the heaven itself, were marked out and verified by a special method, using finely made instruments.

The stars that have been observed to move most slowly, with a single uniform motion, and to keep among themselves a permanently unchanging arrangement and spacing, are called the *fixed* or *non-wandering* stars [Stellae Fixae sive Inerrantes]. Once the course of the Sun has been precisely investigated, these stars deserve the next and chief place in the work of restoring astronomy. For without them neither the Sun nor even the planets [Erraticae] can be reduced to their proper order and harmony. So too, without an exact knowledge of the fixed stars, one is not permitted to measure the positions of the planets accurately. The fixed stars are, after all, certain bright and luminous bodies of heaven, set here and there, and the various passages of the wandering stars across the whole zodiac, in longitude as well as in latitude, are conveniently traced out by reference to them, as though by fixed markers. Thus anyone who tries to lay down some rule for the courses of the planets, and to match that rule with numbers, without first having the positions of the fixed stars restored, is doing nothing whatever, whatever he undertakes.

Moreover, the fixed stars are worthy in their own right of careful and precise observation: for the sake of their light, color, magnitude, multitude, and their most beautiful distribution throughout the whole heaven; and also because they contribute very greatly not only to a more thorough investigation of astronomy proper, but also offer no small help to astrology — which examines the energies of the heavenly bodies — so that it may be properly handled, so far as that is possible.

For, quite apart from the fact that they produce various and sufficiently evident effects of their own, the fixed stars also greatly stimulate the powers of the planets and bring them into act, since they are like mothers, impregnated and made fruitful by these planets as though by fathers, and they perpetually bring forth their offspring toward the Earth, the center of the universe.

So necessary and outstanding is the use of the fixed stars — especially in recognizing and observing the motions of the remaining wandering bodies —

that both the most ancient astronomers and the more recent ones too have had a sufficiently clear understanding of it. And yet how their exact restoration and the marking-out of them that must be sought from the heavens have not been thoroughly carried out by them with that diligence and subtlety of treatment which the task required — this is not yet plain.

The ancients did indeed labor strenuously in this area, especially the famous Timochares [Timocharis], about 300 years before the birth of Christ, and after him Hipparchus of Rhodes [Hipparchus], around the year 120 before Christ. Taking his occasion from a New Star [Nova Stella] seen in his own age (as Pliny [Pliny the Elder] reports), Hipparchus marked out, with the very greatest care, the positions of all the other stars that came distinctly before his sight — so that, for that very reason, it ought not to seem strange that we too, taking the opportunity of a New Star observed in our own time (the one we are dealing with expressly in the present Book), are undertaking the exact recording of the rest of the everlasting stars. After these, Claudius Ptolemy [Ptolemy] too, about the year 140 after the birth of Christ, set himself at Alexandria in Egypt to observe and commit to writing some matters in the progression of these stars; yet, as regards their mutual arrangement in longitude and latitude, he kept entirely to the Hipparchan reckoning-board [Abacus]. Albategnius [al-Battānī] the Arab did the same, around the year 880.

Indeed, King Alphonsus [Alfonso X] too, around the year 1250, devoted himself at great expense to correcting and propagating astronomy; but he changed nothing except by adding a proportionate share of the motion that had occurred in all the stars in the meantime, leaving everything else unaltered — just as that more recent man Copernicus did not either, around the year of Christ 1525, a man who deserved as well of this art as anyone, if anyone did.

But although, through so many transcriptions before the art of typography was discovered, and also through frequent printings less correctly made afterward by means of it, it could easily have come about — over so many intervals of elapsed centuries, with their various confusions and the migrations of the liberal arts — that very many things were corrupted and recorded otherwise than they had been set down by Hipparchus and Ptolemy (especially since those men used Greek notation in indicating numbers, which is very easily liable to transposition): nevertheless, even apart from this corruption introduced in the copying or printing, no slight deviation from the heaven itself was admitted in the very observations and markings-out of the ancients. For, quite apart from the fact that they investigated these matters by too broad an approach — namely by

tens of minutes — they did not, even within the limits of a single sextant of a degree [Sextans unius gradus], reach the whole matter to a point (as the saying goes); rather, by half a degree — very often indeed by a whole degree if not more — they fell short or went over. This deviation of the most ancient astronomers regarding the observations of the fixed stars I judge must be charged not so much to their own negligence, nor to any lack in them of an ardent love for this knowledge, as to the fact that they used instruments and means that were not sufficiently perfect or suitable. Likewise also to the very method they employed in determining the distance of the stars from the equinoctial points [Aequinoctia], which was not without its own twists and difficulties, as we shall see shortly.

The instruments [Organa] that Hipparchus and Ptolemy used for sighting the positions of the stars — and before them Timochares too — were chiefly two: certain armillary spheres [Armillae], and the parallactic instrument, or Rulers [Regulae]; by the former they measured the altitudes of the stars, by the latter their longitudes and latitudes. Yet neither of these instruments supplies the required precision.

The armillary spheres on which Hipparchus and Ptolemy chiefly relied, even though they were no doubt constructed by the generous expense of the Egyptian kings, magnificently and skillfully, out of solid metallic material, were nevertheless — however carefully composed in the end — not subtle enough to probe the very thing we aim at. For if they were so huge as to admit single scruples [scrupula] in the magnitude of their degrees, they would suffice; but by their own bulk and weight, and by their unwieldiness in handling, they turned out less useful. If, on the other hand, they were small and tightly compressed, so as not to be a burden to themselves, then, by crowding the division of the degrees too closely, they rendered it insufficient and less exact. And although some middle course could have been adopted in fashioning and shaping these well, since nevertheless those armillary spheres require so many circles and appurtenances, they are found, through their excessive complication and the disparity of their parts, less handy and inconvenient in use. For they consist of six circles, and these not everywhere turned about on the same poles; and even the one that measures the latitudes — set on the inner circumference of the zodiacal circle — is not freely enough revolved; or, if this be done by means of cross-axes through the middle, then, with the rest of the considerations sometimes standing in the way as a hindrance, by their very multiplicity and incoherence they do not answer precisely enough to their intended use. There is added this too, that the poles of the zodiac, together with their orbs,

are not everywhere in equilibrium with respect to the poles of the equator and of the meridian that support them. As a result, depending on how the inner assembly has been turned, they wander now toward one side, now toward the other, and so they drag the weight of the circles—and indeed the whole instrument—violently away from its proper arrangement, away from the plane that ought to correspond to the celestial circles. The eye does not easily detect this displacement. And the larger the instruments are, the more readily it happens, so that not even moderate-sized or small ones are altogether free of this asymmetry.

For this reason, some years ago I devised certain equatorial armillaries that are not subject to this troublesome wavering and pulling-apart, and with which one may also conveniently investigate the declinations of the stars and their differences in ascension—and above all the exact moments of time, whether by day or by night, whenever the need arises. Three such armillaries, solidly built and of such size that single degrees can take in all the individual minutes, I have ready to hand. One of these is a single machine, larger than the rest, which presents everything most expeditiously and beyond any suspicion of error by means of one-and-a-half circles and a single axle. Moreover, I have reduced the zodiacal armillaries of the ancients to a more convenient and less error-prone compendium, so that they need only four circles, and yet perform everything that those old ones did, but far more conveniently and reliably. Such instruments, already long since, I have had constructed and firmly built, of so great a capacity that they contain the individual minutes distinctly—though whether these satisfy the precision [subtilitas] and certainty I desire, I leave open.

In place of armillaries, certain of the ancients—especially among the Arabs—also used a kind of *torquetum* [Torquetico quodam Instrumento], built up out of round...

flat surfaces. This construction is indeed easier and less costly to make than the armillaries; but for nearly the same reasons I gave concerning the armillaries—and indeed for reasons here far more evident—it proves unwieldy and less suited to reliable observation.

The parallactic instrument [Parallaticum sive Regularum Instrumentum]—by which Ptolemy and certain other of the ancients measured the distances of the Sun, the Moon, and the stars from the zenith—adequately serves, by means of its three rulers, in place of a quadrant or of a very large circle. But if those rulers were to have an adequate size for the individual minutes, and were made, as they ought to be, of metal so that they would not be liable to alteration, then by their own weight—just as I said of the armillaries—they would sag and bend away

from the proper flatness of their surfaces. And if, on the other hand, they were made small, however they might finally be fashioned, they could not bear to measure altitudes to the scruple. This parallaxic instrument, too, does not possess in reserve [in recessu] what it promises on first approach [accessu]: experience itself has taught me this. For I possess two such instruments, made to exact measure and complete, and constructed moreover on different principles; yet they by no means supply the certainty and precision I require, namely such as matches the largest number—six figures [sex Cyphrarum]—of the table of sines [Canonis Sinuum].

I say nothing now of the dioptras, pinnacides [pinnae sights], lenses [Perspicillis], and sighting-holes which both the ancients and the moderns before us have attached to their instruments inconveniently—by which not only is the easy handling of observation impeded, but also no small loss is incurred in the search for certainty. There are likewise certain other matters that it is not now to the purpose to relate in full, which render the instruments of the ancients—the ones with which they contemplated the stars—...

suspect. Concerning these matters, since I have resolved to treat them in a separate book embracing the mechanical part of astronomy—where I shall also disclose my own inventions and the construction and use of the instruments I have built—I forgo any longer discussion of them here.

The other point I mentioned: the practice of the ancients in determining—and thereby rendering less doubtful and more secure—the places especially of the fixed stars, and so also of the planets [Erraticarum], is itself a slippery method of observing, the very one they used. For when they hoped to arrive at a reliable determination of the fixed stars by starting from the Sun, with the Moon (which shares in both day and night) as an intermediary, they did indeed achieve something close to the truth; but to penetrate to its inmost recesses, so that no room would be left for hesitation—to enter by this route—they scarcely, indeed not even scarcely, succeeded.

For let us grant that they had previously known the place of the Sun with the precision required (about which, however, I myself harbor no small doubt). Even so, when, by means of the Moon, they took the interval that separates the Sun from her by the armillaries, and from this derived her place from the Sun, and then at last, after sunset, labored to verify the stars—that which they hoped for they scarcely attained. For they were not able to sight the centers of the luminaries, especially of the Moon, nor even her outermost edge (if they did use it), as sharply as the task required. The Moon's own motion, too, occurring in the

interval of each observation—from the Sun to her, and then from her to some star—presents not a little obstacle; and although this can be guarded against and corrected with moderate diligence, nevertheless the parallax of the Moon [Parallaxis Lunæ], once it becomes involved, disturbs precise certainty. For its workings were not so thoroughly explored by the ancients as they...

supposed. This is sufficiently proved from the Ptolemaic hypothesis of the lunar revolutions: it brings the Moon, when she is closest, nearer to us than is right by about 20 Earth-radii [20 ferè Terræ Semidiametris]. And therefore the parallaxes derived from this hypothesis and limited by it cannot in every respect be correct. And although the difference in so brief a time—the interval that lies between the daytime and the nighttime observations—is not so very great, yet however small it may be, it impedes the precision of the business. There is this further point: the Sun always had to be near the horizon when such a procedure was being carried out; for otherwise the interval of time between the two observations would turn out too great—and the Moon, both because of its own motion and because of the intrusion of parallax, would disturb the operation the more, and not everything would come out consistently. But when the Sun is inclined toward the horizon, it is exposed not only to a greater parallax (which could in some way be corrected by an offsetting allowance), but also to refraction [Refractioni], which is quite appreciable and not so easily investigated or corrected. And since the ancients did not guard against these hindrances—those of refraction especially—they scarcely achieved a fixed rectification of the stars, complete in all its particulars.

But someone will object: in that purer air of Egypt and of the neighboring regions, the refractions are either nil or extremely slight, even near the horizon, and not as they are in this northern thickness of atmosphere. One may indeed say this plausibly, but one cannot prove it. For why should it not be possible that, just as well there as here, vapors rise up from the earth, the sea, and the rivers, and make the air overlying the surface of the earth somewhat denser?

Indeed, it is even more credible that this happens there than with us, seeing that the Sun and the stars are cast in more directly and more strongly there...

send out rays by which they draw up vapors from the waters and from the pores of the earth. Although these vapors are dispersed there more quickly by the Sun's heat — so that they do not so often pass off into dense clouds — they nevertheless cannot, however thinned, be wholly absent, since the earth of its own accord everywhere breathes out certain exhalations. For this reason al-Battānī [Albategnius], even while living in that dry Arabia, preferred to make his

observation around the autumnal equinox, in Libra ☉ [the Sun in Libra], over the vernal one, judging that the air was then clearer and less polluted with vapors.

Therefore what Ptolemy [Ptolemaeus] (not to add the others) set forth in determining the place of the Heart of the Lion [Cor Leonis, Regulus] cannot be free of doubt, since he did not foresee all these aforesaid impediments — and especially the involvement of refraction in the case of the Sun — much less guard against them. Hence too the place of Spica Virginis [the Spike of Virgo], derived through the declination he assigns to it, does not agree with the distance there is between this star and Basiliscus [Regulus]. But these matters must be qualified and reconciled differently, as we shall attempt in their proper place.

There is yet another method by which in antiquity the positions of the stars were investigated by means of the Moon — when she was joined in conjunction with them, or when they crossed the meridian together, the relative places of both were sought. This method is liable to no smaller deviation, though it is not of the grosser kind. For since the place of the Moon, taken by computation, was not held to be so beyond doubt as was supposed, it could not yield a fixed certainty by means of something that was itself uncertain; and the Moon's parallax, too, contributes no little hindrance here. The same judgment must be passed on the culminations of the Moon and of the stars occurring at the same time, which al-Battānī for the most part employed.

To attempt this by lunar eclipses — whether the ancients did so is not sufficiently clear, even though it comes nearer the truth,

— because the place of the Moon, while she is set opposite the Sun, can be ascertained more safely than from the tables; yet even so her relation to the neighboring stars is not perceptible with sufficient precision, since parallax here too introduces some deviation.

It is therefore plain from all this that both the instruments and the methods by which the ancient astronomers undertook the verification of the fixed stars were not in every respect absolutely well established.

Girolamo Cardano [Hieronymus Cardanus], in other respects a renowned philosopher of the Italians of the previous age, makes mention of this last method — of rectifying the stars by lunar eclipses — in the book which he entitled, under an attractive title, the *Supplementum Almanach, or On the Restitution of Times and of the Celestial Motions* [*Supplementum Almanach, sive de Restitutione Temporum et motuum Coelestium*]. He judged this method better than the others, on the ground that the Moon, at the time of a total eclipse, allows even the smallest stars

to be discerned in contact with her or nearby. But how far this is to be trusted is plain from what has already been said, and experience teaches it more fully. As for his claim that, in the same place, in the year 1537 on the second-to-last day of November, he duly re-established by means of the star Venus that the southern and brighter of the Scales of Libra [Lancium Librae] was more southerly and brighter — so much so that he did not hesitate to derive from it the longitudes of all the other stars — this is rather ridiculous than deserving of any credit. For to determine the longitude and latitude of some fixed star by Venus, whose position was then established by no numbers, is the same as if one were to fish out the truth from an ignorant and dumb witness, and to ratify the certain from the doubtful. It need not therefore be any wonder that he rendered the place of that star, according to longitude, one degree with two-thirds [$1^{\circ} 40'$] more advanced than it really was in the heavens itself,

— and likewise all the other stars he set wandering more off course than either the Alphonsine [Alphonsinus] or the Copernican [Copernianus] calculation would warrant, however much eleven other considerations, falling out to the same effect — which nevertheless he does not there mention — he keeps tossing about. But this excessive deflection from the mark, and the incongruous manner of his treatment of the matter, must be forgiven to that man — gifted as he eminently was, and a philosopher shrewd enough in certain other matters, but, for all that, too little of an astronomer, although he peddles a knowledge of this art in not a few passages.

More recent men have attempted this by another kind of reasoning — particularly that great Copernicus of Toruń [Copernicus Toronensis], and the most learned Johann Werner of Nuremberg [Iohannes Vuernerus Noribergensis, Johannes Werner]. They tried to investigate and verify these matters through the declinations of certain stars, especially of Spica Virginis, with the latitude taken into account. Yet while they employ the latitudes of the stars not as previously well enough explored, but merely derived from the old canons; and while they did not rightly know the polar elevation of their own location — that being deduced, as was shown in the prior chapter, from the Sun by a vain endeavor — they did not aim with sufficient accuracy at the goal they desired here; and other difficulties also coinciding all at once, as I shall discuss later in a more suitable place.

There is also a certain other method of investigating the right ascension and declination of the stars, and consequently, by the aid of these, their longitude and latitude through spherical triangles — a method not particularly difficult, and

used by the moderns as well, especially by the most illustrious Prince Wilhelm, Landgrave of Hesse [Vuilhelmus Hassiae Landtgravius, Wilhelm IV of Hesse-Kassel]; one which I too have practiced a number of times, namely by means of the time at which some star crosses the meridian, or stands in a fixed azimuth, given at the same time the altitude of those stars,

— though only once the place of the Sun is first known. For from this it is not hard to compose their right ascensions, and likewise their declinations, and thereupon their longitudes and latitudes as well. But the chief difficulty of carrying this out lies in this: that a moment of time of the kind here required — even down to the very seconds [scrupulis secundis] — cannot be obtained so finely as the task demands. Granted that the Sun's place too is not had exactly, whether by observation or even by some fixed computation — a thing that has not yet been clearly established before now — this is no small obstacle in this matter. Hence it is more fitting to practice this around the equinoctial transits, when, since the place of the Sun varies greatly through declination, it is more safely drawn from observation.

And although the said most illustrious Prince, as well as I myself, have labored greatly at this — so that we took care to have certain very accurate clocks [Horologia] constructed, indicating by a constant rule not merely the hours but also the first and second minutes [scrupula prima et secunda], of which I have three or four at hand, made with the greatest care — nevertheless, for many reasons, of which I have also treated by letter with the most illustrious Prince (as will appear in the *Book of Astronomical Letters* [Epistolarum Astronomicarum Liber]), these clocks cannot be so precise and so correspondent at all times to the celestial standard in a perpetual and even course; and yet such precision is necessary in so subtle a business.

For by whatever skill and dexterity of an ingenious mechanical craftsman those clocks are constructed, they are nevertheless subject to alteration on account of the variation of the air and the winds; nor is this injury sufficiently met if, in the winter season, they are kept in some heated room [vaporario], even at as even a temperature as can be managed. By themselves too, from time to time — however carefully they may at the outset have been

[End of translated text for this opening.]

carefully assembled, they admit some alteration from various causes. And it can easily happen that a few teeth, or some small wheel, being somewhat out of true at a given point, disturb to some degree the continuously equal and proportional

harmony of the motion. In the intervening hours, by their own most minute fractions, these parts may quietly introduce a certain inequality — even though the overall and daily restitution, whether compared against the Sun or against the stars, holds accurately enough. Indeed, the very thread by which the weight is suspended adds somewhat more drag when it hangs at its fullest extent, however fine it may be, than when, in its higher position, the weight had drawn the least of it downward. And although this involves only an exceedingly small difference in the clock's motion, nonetheless — since the very thing I am setting out to investigate is itself something of the utmost delicacy, and an error of four Seconds in the clock entails the loss of a whole First Minute in the star's place — it is not free of every impediment. There are also other things in clocks that altogether undermine the reliability of the certainty and exactness one would need.

What is more, I myself have not left untried another method of measuring this equality of times mechanically, in tune with the heavens: namely, by means of quicksilver, which the chemists [Chymici], since it is the terrestrial analogue of its celestial Star [Mercury], not inappropriately call Mercury. I undertook to accomplish this in the following way, not without expense and labor. I sublimed many pounds of Mercury — by a process known to the chemists — three or four times, casting off the dregs, and each time revived it by a certain method explored by myself, until it shed its grosser impurities. Once it was thus purified, I had it placed in a certain large glass vessel, prepared for this same use, which lower down ran to a point with

a very narrow and round opening. Then first, when the Sun or some star crossed the Meridian, I allowed the mercury to flow, and continuously, until that same heavenly body returned again to the Meridian — with this further precaution taken: that by means of a second glass vessel projecting above the first (certain supports being interposed) the lower vessel should be kept as nearly as possible perpetually full at the same level, by having dripped into it from the upper one just as much of the mercurial liquid as the lower one was losing by emptying out below — so that the weight of the mercury contained should remain constant with itself, and should drive out the flow uniformly. In this way, by a single Revolution, I weighed the Mercury collected and placed on the balance. From this, weighing out proportionally by other scales how much should correspond to single Hours, Minutes, and Seconds of the running Mercury, I gathered the result: so that by this method, whenever I pleased and some star was observed on the Meridian, I could determine from the weight of the Mercury that had flowed out from noon how many Hours, Minutes, and Seconds had elapsed from the

Meridian, and from this — once the Sun's place was brought in — perceive the Right Ascension of any given star. A laborious and costly undertaking, to be sure. And so in this way too the dictum of the Spagyric Philosophers [Philosophi Spagirici] was verified: *In Mercury is whatever the Wise seek*. Nor, content with Mercury itself — pliant though it is to every use and transmutable into very many Metamorphoses — did I stop there. Through the highest planet too, Saturn, that ponderous Old Man (for so the chemists rightly call lead), purged of its impurities by the force of Vulcan and reduced by calcination into the finest powder, I likewise wished to make trial — inasmuch as Saturn, being as it were the supreme of the Planets and the slowest, and presiding

over contemplation and a more sublime Wisdom, might also, through a Metal assimilated to itself here on Earth, lend aid to our arduous and difficult endeavor. And so Saturn and Mercury, by their joint Operations, might expedite this inquiry — since, according to the Astrologers as well, the conjunction of those two bodies, or their mutually benevolent radiation (especially if some change of the Moon coincides with it), or indeed a more benevolent aspect, are believed to contribute more than the other signs toward depth of intellect and skill and contemplation, and toward unwearied steadfastness of labor.

Now I made use of the Metals above all in this weighing-out of the divisions of Time, because they are heavier than the rest and, in little time, let down much weight through a tiny opening, and moreover are not so subject to Aerial change as the things that could be made for the same use out of Vegetables or Animals.

But to tell the matter as it really is: not only did that crafty Mercury — just as it eludes Astronomers in the Sky and chemists on Earth — render our efforts vain as well; that grave Saturn too, constant in his other ways, relaxed nothing of his sly and clandestine habits, and however laborious he is, nonetheless shirked all the labor.

I have recounted all these foregoing things at such length for this reason: that students of this Art may understand how great an undertaking it is to fix beforehand, with the utmost exactness, the distance of even a single Star in the Sky from the Equinoxes or the Solstices; how much both the Ancients and certain of the Moderns [Neoterici] have labored at this here in vain; and that I might at the same time show with how great longing, with how great effort and exertion, and by methods how costly too and full of difficulty, I myself

have striven after this very thing for many years now. And from this they may also recognize, at least in part, how much it matters to construct an accurate

restitution of the Fixed Stars [Affixae Stellae], so that at least a single one may be given accurately, with respect to both longitude and latitude.

But if anyone supposes that I have said something here to the effect that I disparage the arduous endeavors of the Ancients, which I always extol and without which, at present, either nothing at all or only very little could be accomplished in the restoration of this Art — or that I disparage and utterly scorn the praiseworthy efforts of the Recent authors as well — and that I have presumed to speak too arrogantly, and have brought myself to think this in my mind: such a person is not lightly unjust to me, nor sufficiently a lover and devotee of the more hidden Truth, which alone we look to here, who pronounces nothing for anyone's favor or out of hatred, or through any sort of disdain. For Truth ought, before all things, to be our friend — Truth, the Queen of all virtues. But among the intelligent, and those who weigh all things soberly and sincerely, there will be no need (I trust) of this excuse.

[Margin: 18]

Since, then, the restitution of the Inerrant Stars [Stellae Inerrantes], cut off from where their places should lie, would be liable to so many and such great twists and impediments — as I pondered, and long and much contemplated, by what method at last I might carry this business through without any suspicion of deviation — behold, the Sky itself, as if unhopd for, generously granted an excellent and sufficient Occasion for rightly recognizing and arranging its own Stars. And so in the Year 1582, when the Star of Venus showed itself by day together with the Sun, for a long while, in spring Air that was of the purest — both before and after the Meridian, and in this case too — so apparently to view that, by its instruments [Organa], its position and its distance from the Sun could be readily and distinctly taken,

they could. And so, since the heavens had offered me this most convenient opportunity to satisfy my long-standing wish surely, safely, and with the least possible effort, I judged that it should by no means be passed over: namely, to verify the fixed stars [Affixa Sidera] by means of the planet Venus as an intermediary, taking the Sun's place over to them. This is far more convenient and reliable than carrying it out by means of the Moon, which I had done earlier with less success (for the reasons given above). For Venus, since it occupies only a tiny place in the heavens in its visible diameter, and is far slower in its proper motion than the Moon, can also be discerned correctly. Nor are its parallaxes [Parallaxibus] so conspicuous — intricate as the matter is (granted that a careful precaution must be applied to these together with the refractions

[Refractionibus]). I therefore judged Venus the most suitable body to set in charge of carrying out this task, and I was glad that she did not disdain to favor my aspirations as they reached upward, to aid them and to come to their relief, by showing her favorable light and her lovely face even in the daytime.

And so, setting aside and leaving behind that morose, difficult Saturn and that crafty, deceitful Mercury, I turned my eyes and my whole attention toward the friendly and favorable light of Venus, which lent its favor to my efforts even by day. For in this way she came to my aid — not only in the heavens, by her bodily and visible presence, present both in twilight and at night, but also on the earth, in the metal that suits her nature: namely in copper [Aere], rendered purer and more lustrous by means of the stone cadmia [lapidem Cadmium], from which the instruments fit for this observation could reliably be made. And so she did not refuse, out of her kindly disposition, to support me and to lend a helping hand.

But so that what I intend may not be put off too long, and so that I may not detain the attentive and eager reader longer than is proper, I will now explain by what method, with the help of Venus, I undertook the accurate verification of the fixed stars [Affixarum] by means of the Sun.

And this I will set out not only with respect to that year I spoke of — the year [']82 — but also with respect to several of the years that followed.

I used to observe in the daytime, whenever the Sun and Venus could be seen together, and when they were situated at the greatest elevation above the horizon that could be had, their distance from one another. This I measured by means of a certain Astronomical Sextant instrument [Sextantis Astronomici Instrumentum] of our own devising (whose construction and form I will explain later), supplying everything most precisely, down to single scruples [scrupula] with some fractions of these as well, free from any suspicion of error — and on this principle: that one observer should sight a star [Stellam] through certain little slits in the forward cylindrical sighting-vane [Pinnacidio priori Cylindrico], which is set parallel to the center of the instrument; while the other observer (for two of them must be present at once) admits into the second, movable sighting-vane [mobile Pinnacidium] the shadow cast by the cylinder from the Sun, so that he makes that shadow equal between the two lines. And so, by collimating several times — toward the Sun and toward Venus — the distance was taken exactly by the removal of each sighting-vane. The altitude, too, both of the Sun and of Venus, and sometimes also the azimuth in which they were situated, was noted at the same time, as the work required. Moreover, the declination [Declinatio] of these bodies, by means of the equatorial armillae [Armillas Aequatorias], was not

neglected, in whatever position outside the meridian; and the meridian altitude as well, by means of the quadrants [Quadrantes], whenever it was granted — the same being confirmed and verified.

Then by night, when the Sun, sunk below the horizon, allowed the twinkling of the stars to be seen, and when Venus herself, still brightly shining above the horizon, glittered among them, I investigated, by means of the same sextant, the distance of certain particular and chief stars lying near the zodiac from this star Venus, applying then also the declination [Declina-

-tione] and the altitude of each, and sometimes the azimuth too. And in every case, both by day and by night, I diligently recorded and made use of the moments of time at which each of the observations was completed, so that — once the proper motion [motionis propriae] of Venus had been taken into account, and her place corrected by means of the Sun in the daytime, and then collated with the proportion of her advance [promotionis proportione] meanwhile made — I might rectify the place of the proposed star [Stellae propositae]. And this was first done with respect to its right ascension [Ascensionem Rectam] — which, the equatorial coordinate being applied together with its declination [Declinatione], was readily resolved into longitude and latitude [Longitud. et Latitud.] with respect to the ecliptic [Ecliptica].

And by this method I carefully investigated the places of several fixed stars [Affix. Stellarum], and examined these same places further by their distances from one another, and at last brought everything back to that bright star which is above the head of Aries [supra Caput Arietis], so that the determination of the rest might be sought from it — referring it deliberately to the completed year 1585 [Annum 1585 completum], as though to a common intermediary. I set aside that star which is first in number, the one Copernicus [Copernicus] used, because it is small, and is not sufficiently open to observation, especially when the Moon is shining. Now out of more than a hundred reductions [aversionibus] made on this reasoning in the aforesaid year, I will set forth only three particular and choice ones, and expand them by way of numerical demonstration — on which the hinge of the very matter we have proposed turns.

I also applied, in these cases, wherever the parallaxes of the Sun and of Venus were involved, and likewise the complication of the refractions [Refractionum] as one draws near the horizon, their resolution and a suitable correction.

But lest these very complications of the parallaxes and refractions [Parallaxium atque Refractionum implicationes], whether they had been duly corrected or not,

should leave some scruple of doubt in the mind — and lest the few scruples that remained should raise suspicion against the restitution of the fixed stars [Restitutio Fixarum] thus carried out — I undertook so great a matter by yet another method, deeper and fuller in [its] investigation [indagine

-gine], and in certain other following years as well. For I observed, with what acuteness I could, that whenever Venus could also be viewed by day as a morning star [Eoas], I derived from it — by collating it then (as before) with the fixed stars — their places, having afterward verified Venus herself against the Sun's rising. And so I compared and examined several years' worth of morning observations, made with the utmost diligence, together with the evening ones obtained with no less care, weighing everything circumspectly, whether as applied to those same stars or to any others whatever.

Now I judged that all these observations, both the morning [Eoas] and the evening [serotinas] ones, should be compared with one another in such a way that, whenever Venus and the Sun were at an altitude above the horizon, and in a declination and a distance from the earth, as nearly alike as could possibly be, the comparison between them should especially be made. For in this way the refractions and parallaxes would either cancel each other out by their very nature, or be corrected by the intervening distinction that amends them; the obstacles would be removed; and no further doubt would be left in the mind, the execution of this procedure having been scrupulously carried out.

And although within the most recently elapsed seven-year period [Septennium] I obtained from the heavens very many such morning and evening collations for duly arranging and examining the fixed stars, it nevertheless seemed good to select at least twelve of the more suitable and exact ones, and to set them out here — so that, taken together, our argumentations and confirmations for correcting the places of the fixed stars [in Fixarum locis emendandis] may be fifteen in all. These I will now freely impart to the devotees of the astronomical art, having first set down those three which we obtained for the evening star [Hesperum] separately in the year [']82 (as has been said several times). Afterward I will set out those twelve, regarding both the morning star [Luciferum] and the evening star [Hesperum].

ENUMERATION OF FIFTEEN SELECTED OBSERVATIONS

made by means of the planet Venus — compared with the Sun by day and with the fixed stars by night — from which the right ascensions of certain fixed stars are accurately derived (above all that of the brighter star above the head of Aries in its constellation), all of them reduced to the completed year 1585;

&

First: from three observations made in the year 1582 toward Hesperus, around the western quarter of the sky, with only the considerations there taken into account.

In the year 1582, on 26 February, in the afternoon, at 3 hours 35 minutes, the distance between Venus [♀] and the center of the Sun [☉] was observed by the triangular sextant to be $46^{\circ} 10\frac{1}{2}'$. About the same time the declination of Venus was found to be $15^{\circ} 21\frac{3}{4}'$ north [Borea], and at the same moment the altitude of the Sun was $15\frac{1}{6}^{\circ}$ and the altitude of Venus $48\frac{1}{4}^{\circ}$. Given these data — since the place of the Sun is known from its own proper motion as restored — the right ascension of Venus, and from it likewise the right ascension of the bright star of Aries [Lucidae ♈], was investigated in the following manner.

The place of the Sun for this time is, by our calculation, $17^{\circ} 49' 42''$ of Pisces [♊]; and since this is the true place, by this reasoning it was reduced to its apparent place. The parallax of the altitude of the Sun is $0^{\circ} 2' 55''$; of longitude, $0^{\circ} 2' 11''$; of latitude, $0^{\circ} 1' 53''$. Therefore, when the parallax of longitude is subtracted from the true place of the Sun, the apparent place remaining is $17^{\circ} 47' 31''$ of Pisces, to which corresponds the apparent right ascension of part [partes] $348^{\circ} 47' 30''$. The apparent declination is $4^{\circ} 52\frac{1}{4}'$ south [Merid.]. And since the observed declination of Venus is also given as apparent, and likewise its distance from the Sun, the ascensional difference of the two becomes easily known. But before that is investigated, it is fitting first to determine what the parallaxes of Venus were at this time, by this method.

In the figure set out, let A be Venus [♀] and C the center of the Earth; the rest is clear enough of itself. Therefore in the right triangle DBC, the side BC is given as the semidiameter of the Earth, taken as 100000, and the angle DBC is equal to its opposite angle EBA, which is known through the complement of the altitude of

Venus to be $41^{\circ} 30'$. Hence, by the practice of plane triangles, the side DC is found to be of part 66262. Then in the triangle DAC, since the side CA is established — namely the distance of Venus from the Earth according to the Copernican hypotheses [Hypotheses Copernianas], by our

Diagram. A circle (the Earth's orbit / sphere of the elements) with center G, marked by the orthogonal diameters EG (top) to its foot, and HF horizontally (H left, F right), with the bottom vertex labelled G' [the foot of the vertical diameter]. A small inner circle is drawn about the center. Within the construction, point A lies in the upper right; from it lines are drawn inward to B and D, forming the parallax triangle. The figure illustrates the right triangle DBC and triangle DAC of the surrounding text.

- E (top): top of vertical diameter
- A (upper right): Venus [φ]
- B (center-upper, on inner circle): apex of the parallax angle
- D (just left of center): foot of the perpendicular
- G (center): center of the Earth [the text's point C]
- H (left): left end of horizontal diameter
- F (right): right end of horizontal diameter
- (bottom): foot of the vertical diameter [printed as a repeated diameter terminus]

[Note: the text names the Earth's center "C," whereas the engraved figure labels the central point G; the central label is read as G on the plate.]

reasonings in this matter not at all discordant, the semidiameters of the Earth being 815, and the side DC found before, while the angle at D is right — therefore by the laws of triangles the angle DAC was given as $0^{\circ} 2' 48''$, which determines the parallax of the altitude of Venus.

But for investigating the parallax with respect to right ascension: let A in this figure be the pole of the horizon, the portion of which FGH represents; B the pole of the equator, shown by IGK; CE the parallax of altitude. From this it is plain that DC corresponds quite closely to the parallax of right ascension to be sought. The triangle ABE has its side BA given as part $34^{\circ} 5\frac{1}{4}'$ through the distance of the poles of the horizon and the equator; EA is $41^{\circ} 30'$ through the complement of the altitude of Venus; RE is part $74^{\circ} 38\frac{1}{3}'$ [r e, part. 74. min. $38\frac{1}{3}$], the complement of the declination of Venus. And so the angle AEB will not be hidden: $9^{\circ} 48'$. The triangle CED, right-angled at D, has its angle CED known — the same as AEB, just found — and the side CE, the parallax of altitude, $0^{\circ} 2' 48''$, exhibiting the value

given above; whence, through the operation of triangles, the side DC is found to be $0^{\circ} 0' 32''$, which measures the sought parallax of the right ascension of Venus. Now we shall proceed to determine the ascensional difference of Venus [☿] and the Sun [☉].

Diagram. A great circle with several arcs of great circles crossing through its interior, representing the intersecting horizon, equator, and altitude/declination circles. Labelled points around and within the circle: A and B near the top, C and D toward the upper interior, E in the interior, I at the left, F at the lower left, L and G' at the bottom interior, H at the right, K at the lower right. The arcs form the spherical triangles ABE and CED of the surrounding text (the parallax-of-right-ascension construction).

- A (top, slightly left): vertex
- B (top, right of A): vertex
- C (upper interior): vertex
- D (just below C): vertex
- E (interior, below D): vertex
- I (left): point on circle
- F (lower left): pole of the horizon region
- L (lower interior): point
- G (bottom interior): point
- H (right): point on circle
- K (lower right): point on circle

Diagram. A spherical triangle drawn as a tall curvilinear figure: apex A at top, with the two sides curving down to the base. Point C lies on the left side partway down, D at the lower left, B at the lower right corner with E just below it. The figure represents triangle BAC, where A is the pole of the equator, B the Sun, and C Venus, used to find the ascensional difference (angle CAB).

- A (apex, top): pole of the equator
- B (lower right): the Sun [☉]
- C (left side): Venus [☿]
- D (lower left corner): point on the equator portion
- E (lower right, below B): point on the equator portion

In this prescribed figure let A be the pole of the equator, B the Sun, C Venus, by whose places the portion of the equator intercepted is indicated by DE; from the pole let arcs of a great circle descend. It plainly remains, therefore, that the angle

CAB to be sought measures the ascensional difference of both Venus [☿] and the Sun [☉]. Accordingly, since in the triangle BAC all three sides are given — for CA is the complement of the declination of Venus, $74^{\circ} 38\frac{1}{3}'$; BA is established from the declination of the Sun, since, being southern, it is added to the quadrant, part $94^{\circ} 52\frac{1}{4}'$; and the side BC is the very distance between the Sun and Venus as observed, $46^{\circ} 10\frac{1}{2}'$ — from these three known sides, by the operation of the Doctrine of Triangles, the angle BAC is found, part $41^{\circ} 54' 58''$, which shows the difference of right ascension between the Sun and Venus.

When we add this to the right ascension of the apparent Sun known above, the apparent right ascension of Venus results as $30^{\circ} 42' 28''$, to which, when the parallax of right ascension $0^{\circ} 0' 32''$ is added, together with the refraction also (insofar as it bears on the equator, known otherwise as $0^{\circ} 0' 30''$), the true right ascension of Venus for this time will be $30^{\circ} 43' 30''$ — which is what we needed first to learn.

On the same day, in the afternoon at 7 hours 5 minutes, the distance between Venus and the Eye of the Bull [Oculum ☿, Aldebaran] was observed as part $30^{\circ} 59'$, and at the same time the declination of Venus was part $15^{\circ} 25\frac{1}{8}'$ north [Borea]. Its altitude was $27\frac{1}{2}^{\circ}$; but we have obtained the declination of the Eye of the Bull [☿] elsewhere, from reliable observations, as $15^{\circ} 36'$. Given these, the ascensional difference of both was investigated in this manner.

In this diagram let A be the pole of the equator, B Venus [☿], C the Eye of the Bull [☿], DE the portion of the equator to which the arcs of a great circle, AD and AE, descend from its pole through the given places at B and C.

Diagram. A tall curvilinear spherical triangle: apex A at top, sides curving down to the base DE. Point C lies on the left side, B on the right side partway down; D at the lower-left corner, E at the lower-right corner. The figure represents triangle BAC, with A the pole of the equator, B Venus, C the Eye of the Bull (Aldebaran).

- A (apex, top): pole of the equator
- B (right side): Venus [☿]
- C (left side): the Eye of the Bull [☿, Aldebaran]
- D (lower-left corner): point on the equator
- E (lower-right corner): point on the equator

The triangle BAC has given sides: CA is part $74^{\circ} 24'$, the complement of the declination of Aldebaran; BA is part $74^{\circ} 34\frac{2}{3}'$, the complement of the declination of Venus; BC is part $30^{\circ} 59'$, the distance between Aldebaran and Venus.

Therefore the angle CAB will not be hidden: part $32^{\circ} 11' 6''$, which is the sought ascensional difference itself.

But so that the right ascension of Venus known for the earlier time may be accommodated here, on account of the diurnal motion of Venus with respect to the equator as it then was — namely $0^{\circ} 0' 57''$ — there is added the proportional part appropriate to the 3 hours 30 minutes that elapsed between the two observations: the [diurnal arc] of Venus toward the Sun and toward Aldebaran being $0^{\circ} 8' 18''$, and the ascension of the latter at this final time will be $30^{\circ} 51' 43''$. And since Venus then had an altitude of $27\frac{1}{4}^{\circ}$, the reckoning of parallax must also be had in this place. Therefore, following the figure for finding the parallax of altitude, as noted above, the parallax of this altitude is $0^{\circ} 3' 45''$; while according to the other figuration the parallax of right ascension is found to be $0^{\circ} 2' 7''$. When this is subtracted from the ascension directed to this last time, the apparent right ascension of Venus remains, $30^{\circ} 49' 41''$. And if to this we add the ascensional difference between Venus and Aldebaran investigated a little before, the right ascension of the Eye of the Bull [$\odot$ — Oculi γ] is composed, part $63^{\circ} 0' 47''$, which was sought. The ascensional difference between Aldebaran and the bright star of Aries [Lucidam γ], whose right ascension we most wish to know, is established from reliable observations as part $37^{\circ} 3' 15''$. When this is taken away from the right ascension of the Eye of the Bull [γ], the right ascension of the bright star of Aries [γ] remains, part $25^{\circ} 57' 32''$. So that this may be transferred, according to our proposed plan, to the completed year of Christ 1585, let there be added $0^{\circ} 3' 12''$ for 3 years and

10 months, account being taken of the precession of the fixed stars made in the meantime (of which in its own place); and thus the right ascension of the bright star above the head of Aries [γ] will appear as part $26^{\circ} 0' 44''$, which we have resolved to investigate above all the rest.

II.

Investigation from the observations of the same [Venus] on 20 March.

In the same year [15]82, on 20 March, at 2 hours 25 minutes in the afternoon, there was observed in the same manner as before the remoteness between the planet Venus and the center of the Sun, part $43^{\circ} 50'$ exactly, with the altitude of the Sun at part 31° , and the elevation of Venus indeed at 57° . About the same time the observations gave the declination of Venus as north, part $23^{\circ} 2'$. Moreover,

from our own tables the true longitude of the Sun was part $9^{\circ} 33' 19''$ of Aries [Υ]. The parallax of altitude is $0^{\circ} 2' 34''$; of longitude, $0^{\circ} 1' 47''$; of latitude, $0^{\circ} 1' 50''$. And so the apparent longitude of the Sun is part $9^{\circ} 31' 32''$ of Aries; through subtraction of the parallax from the true longitude, the apparent right ascension answers as part $8^{\circ} 46' 55''$, and the apparent declination as $3^{\circ} 45' 34''$ north [Borea]. Given these, the ascensional difference between the Sun [$\odot$] and Venus [ζ] is found in this manner.

Let A be the pole of the equator, B the Sun [$\odot$], C Venus [ζ]. In the triangle BAC, since all the sides are known — for BA is part $86^{\circ} 14' 26''$; the complement of the apparent declination of the Sun, CA, is part $66^{\circ} 58'$; the complement of the observed declination of Venus, BC, is indeed part $43^{\circ} 50'$; the distance between the Sun [$\odot$] and Venus [ζ] is made manifest by observation — therefore, by the triangular method of computation, the angle CAB is given, part $40^{\circ} 44' 49''$, which designates the arc intercepted on the equator between the Sun and Venus.

Diagram. A tall curvilinear spherical triangle: apex A at top, sides curving to the base DE. Point C on the left side, B on the right side; D at the lower-left corner, E at the lower-right corner. The figure represents triangle BAC, with A the pole of the equator, B the Sun, C Venus.

- A (apex, top): pole of the equator
- B (right side): the Sun [$\odot$]
- C (left side): Venus [ζ]
- D (lower-left corner): point on the equator
- E (lower-right corner): point on the equator

Let this ascensional difference be added to the right ascension of the apparent Sun investigated before, and the right ascension of Venus comes out as part $49^{\circ} 31' 44''$. But the parallax by which this ascension ought to be corrected was investigated thus.

The distance of Venus from the Earth being 623 semidiameters of the Earth, whence at the elevation of part 57 above the horizon there corresponds a parallax of 3 minutes 0 seconds. Therefore, in the next following figuration, the side BA is the interval of the poles of the horizon and the equator, part $34^{\circ} 5\frac{1}{4}'$; CA the complement of the altitude of Venus, part $33^{\circ} 0'$; the side BC is part $66^{\circ} 58'$, the complement of the apparent declination of Venus. From these three given sides, then, the angle BCA is not hidden: part $4^{\circ} 49'$. The triangle DCE, right-angled by drawing a perpendicular at E, has its known side

the side DC, $0^{\circ} 3' 0''$, since the parallax of altitude [parallaxis altitudinis] is itself this, and the angle DCE is equal to ACB, already found. Therefore, by the principles of triangles, the side DE came out to $0^{\circ} 0' 15''$ — the parallax of right ascension of Venus [parallaxis ascensionis rectae]. When this is now subtracted from her right ascension, found above from the Sun, there remains the right ascension of Venus, $49^{\circ} 31' 29''$. This had to be determined first, before one could proceed to the right ascensions of the fixed stars.

Diagram. A circle representing the sphere, with points marked around and across it. The upper region carries a small lettered cluster (the local parallax triangle) and several great-circle arcs crossing the disc.

- A: near the top of the circle
- B: at the top, slightly right of A
- D: just below and left of A/B (apex of the small triangle)
- E: just below D (within the cluster)
- C: just below E (within the cluster)
- F: at the left edge of the circle
- G: at the left edge, below F
- I: at the right edge of the circle
- H: at the lower right of the circle
- L: lower left, on an inner arc
- K: at the bottom-center, on an inner arc

On the same day, at 8 h 11 m P.M., the distance between Venus and the heel of the foot of Gemini [calx pedis Geminorum] was observed with the same instrument to be $36^{\circ} 32'$. At the same time, the distance between the Sun and Venus was taken, and likewise at this moment the declination of Venus was $23^{\circ} 4\frac{3}{4}'$ north [Borea]. The declination of the heel of the foot of Gemini was also northern, $22^{\circ} 38\frac{1}{2}'$. From this, the difference of ascension between the two — Venus and the star of Gemini — was thoroughly worked out by means of triangular calculation, according to the following figure.

In the triangle BAC, the side BA is $67^{\circ} 21\frac{1}{2}'$, the complement of the declination of the heel of the foot of Gemini relative to the pole of the equator. The side CA is $66^{\circ} 55\frac{1}{4}'$. The distance of Venus from the same pole, the side BC, is $36^{\circ} 32'$ — this being the observed distance itself. Therefore, when the calculation was carried out according to the doctrine of triangles, the angle BAC came to $39^{\circ} 46' 13''$, representing the ascensional difference between Venus and the heel of the foot of Gemini.

But because the altitude of Venus on this occasion was $23\frac{1}{2}^{\circ}$, a different parallax was thereby caused with respect to altitude and right ascension. Before we have applied here the right ascension determined from the Sun, we shall examine what parallaxes Venus could here introduce.

Diagram. A tall, pointed spherical triangle with apex A at the top; near the base, a short arc cuts across with points B (left), C (right), D (lower left), and E (lower right), forming the small parallax sub-triangle.

- A: apex at the top
- B: at the left of the base region
- C: at the right, just below the base arc
- D: at the lower left (base)
- E: at the lower right (base corner)

Therefore, with Venus's distance from the Earth remaining the same — 623 Earth-radii [semidiametri Terrae] — the parallax at this assumed altitude will be $0^{\circ} 5' 4''$, which by this same reasoning we shall refer to the circle of the equator in the figure that follows.

Since in the triangle BAC all the sides are known — BA, $34^{\circ} 5\frac{1}{4}'$, the distance of the pole of the equator from the zenith; CA, $66^{\circ} 30'$, the complement of the altitude of Venus; BC, $66^{\circ} 55'$, the complement of the declination of Venus as seen — therefore, the operation being carried out according to the principles of triangles, the angle ACB came out to $37^{\circ} 13'$. Furthermore, in the right triangle CDE, right-angled at E,

since the angle at C became known, and the side DC — the parallax of altitude — $0^{\circ} 5' 4''$, is given, the side DE will not remain hidden: $0^{\circ} 3' 4''$, which measures the parallax of right ascension of Venus. By this, the right ascension of Venus determined from the Sun, having been applied here, will be corrected.

Diagram. A semicircle (the half-sphere with the horizon as the diameter at the foot). Near the top is a small lettered cluster forming the parallax triangle, with arcs descending to the horizon.

- A: at the top of the semicircle
- B: at the top, to the right of A
- D: just below A (apex of the small triangle)
- C: below and left of D (within the cluster)
- E: just below D (within the cluster)

Now because the diurnal motion of Venus with respect to the equator is $0^{\circ} 45\frac{1}{2}'$ per 5 hours, to the 46 minutes by which this observation of Venus from the fixed star followed that other one made from the Sun there correspond $10' 55''$. Added to the right ascension of Venus found earlier, this constitutes for the time of this observation the true right ascension of Venus, $49^{\circ} 42' 24''$. When the parallax of ascension determined for this latter time is subtracted from it, there remains the apparent right ascension of Venus, $49^{\circ} 39' 20''$.

If we now add to this the arc of the equator between the heel of the foot of Gemini and Venus, found above, the right ascension of the heel of the foot of Gemini will be $89^{\circ} 25' 33''$. The ascensional difference between this heel of the foot of Gemini and the bright star of Aries [Lucida Arietis], established by other reliable observations, is $63^{\circ} 28' 10''$. When this is subtracted from the ascension of the heel of Gemini, it leaves the right ascension of the bright star of Aries, $25^{\circ} 57' 23''$. Let there be added to this $0^{\circ} 3' 9''$, for 3 years and $9\frac{1}{2}$ months, by the rate at which the annual motion of the eighth sphere [sphaera octava] proceeds — very nearly $51''$ — and the right ascension of the bright star of Aries will be $26^{\circ} 0' 32''$, for the completed year of Christ 1585, which we have set out to investigate.

III.

To investigate the same right ascension from the observations of 3 April.

For the inquiry into the right ascension of the fixed stars, we have likewise brought into consultation observations taken from the heavens in the same year, 1582, on 3 April. For on the said day, at 1 h 40 m P.M., the distance between the Sun and Venus was found to be $38^{\circ} 38\frac{3}{4}'$. The declination of Venus, by observation, appeared at the same time to be $25^{\circ} 47\frac{1}{2}'$ north. The altitude of the Sun was then $39\frac{1}{2}^{\circ}$, the altitude of Venus $58\frac{5}{8}^{\circ}$. The longitude of the Sun, derived from observing its proper motion, was $23^{\circ} 13' 52''$ of Taurus [Taurus, ♉]. The parallax of altitude was $0^{\circ} 2' 20''$; of longitude, $0^{\circ} 1' 30''$; of latitude, $0^{\circ} 1' 47''$. Accordingly, the apparent right ascension of the place of the Sun comes out to $21^{\circ} 28' 3''$. The apparent declination of the same was $9^{\circ} 1' 13''$ north. The difference of ascension, then, between the Sun and Venus, following the equator's track, is demonstratively built up from these data in the manner set out next.

Let A in the assigned figure be the pole of the equator, B Venus, C the Sun. In the triangle BAC, since all three sides are given — BA, $64^{\circ} 12\frac{1}{2}'$, the complement of the declination of Venus; CA, $80^{\circ} 58' 47''$, the complement of the declination of the Sun; and the side BC, $33^{\circ} 58\frac{3}{4}'$, the distance between the two — the angle BAC is

found to be $36^{\circ} 43' 5''$, which makes manifest the equatorial difference between the Sun and Venus. Added to the right ascension of the Sun, this yields the right ascension of Venus, $58^{\circ} 11' 8''$. Now the distance of Venus from the Earth being 501 Earth-radii, from which it is gathered that the parallax in the circle of altitude was $3' 33''$, let us apply this parallax to the equator in the following way.

Diagram. A tall pointed spherical triangle with apex A at the top; near the base a short arc carries the points B (left), C (right), with D (lower left) and E (lower right) forming the small parallax triangle at the foot.

- A: apex at the top
- B: at the left of the base
- C: at the right, just below the base
- D: at the lower left (base)
- E: at the lower right (base corner)

In the triangle BAC, the side AB is $34^{\circ} 5\frac{1}{4}'$, the distance of the poles of the horizon and the equator; CA, $31^{\circ} 10'$, the complement of the altitude of Venus; BC, $64^{\circ} 12\frac{1}{2}'$, the complement of the declination of Venus as seen. Hence, by the procedure of triangular computation, the angle BCA comes out to $12^{\circ} 16'$. Then, in the right triangle DCE, the side BC [recte: DC] is the parallax of altitude, $0^{\circ} 3' 33''$. The angle DCE is already established; therefore, by the principles of triangles, the side DE is produced, $0^{\circ} 0' 45''$ — the parallax of right ascension sought. When this is subtracted from the right ascension of Venus found above from the Sun, it leaves the true right ascension of Venus, $58^{\circ} 10' 23''$.

Diagram. A circle (the sphere) with the same disposition of points as the earlier full-circle figure: a small lettered cluster (the parallax triangle) near the top, with several great-circle arcs crossing the disc.

- A: near the top
- B: at the top, right of A
- D: below A/B (apex of the small triangle)
- E: just below D (within the cluster)
- C: below E (within the cluster)
- F: at the left edge
- G: at the left edge, below F
- I: at the right edge
- H: at the lower right
- L: lower left, on an inner arc

- K: at the bottom-center, on an inner arc

On the same day, at 8 h 51 m P.M., the distance between Venus and the southern head of Gemini [meridionale Caput Geminorum] was observed with the same instrument to be $45^{\circ} 37'$. The declination of Venus around this time was $25^{\circ} 43'$ north. The declination of the southern head of Gemini in the same year was $28^{\circ} 57'$. From these data, the equatorial distance of Venus and the lower head of Gemini [inferior Caput Geminorum] has been worked out by calculation, in such a way that it will easily become clear to those who consider attentively what follows.

Let B be the lower head of Gemini, C the star Venus. The triangle BAC has all its sides given: BA, $61^{\circ} 3'$, from the complement of the declination of the head of Gemini; CA, $64^{\circ} 12'$, from the complement of the declination of Venus; BC, $45^{\circ} 37'$, the distance between the two themselves. The triangular ratio accordingly supplied the angle BAC, $51^{\circ} 39' 11''$, which exhibits the equatorial distance between Venus and the lower head of Gemini.

Diagram. A tall pointed spherical triangle with apex A at the top; near the base, a short arc carries B (left) and C (right), with D (lower left) and E (between B and C) marking the small parallax triangle at the foot.

- A: apex at the top
- B: at the left of the base
- C: at the right, on the base arc
- E: at the lower right, just below C
- D: at the lower left (base corner)

At the time of this observation the altitude of Venus was 17° ; and so its parallax in the vertical circle was $0^{\circ} 6' 34''$, which, deduced lengthwise with respect to the equator, is as follows. The side BA is $34^{\circ} 5\frac{1}{4}'$, the distance of the poles of the equator and the horizon [Finitor]; CA, $73^{\circ} 0'$, the complement of the altitude of Venus; BC, $64^{\circ} 12'$, the complement of the declination of Venus, from which the angle ACB became known, $35^{\circ} 29'$. Then in the triangle DCE, since the angle at C is known, together with DC, $0^{\circ} 6' 34''$, let the parallax of altitude be taken; by the operation, the side DE is produced, $0^{\circ} 3' 49''$ — the required parallax of right ascension.

Diagram. A semicircle (the half-sphere with the horizon as its diameter). Near the top is a small lettered cluster forming the parallax triangle, with arcs descending to the horizon line.

- A: at the top of the semicircle
- B: at the top, to the right of A
- D: just below A (apex of the small triangle)
- C: below and left of D (within the cluster)
- E: just below D (within the cluster)

The difference of time between the observation of Venus from the Sun and the other taken from the head of Gemini is 7 h 13 m. To this, given Venus's diurnal motion with respect to the equator of 29 minutes, there corresponds an intermediate motion of $0^{\circ} 8' 43''$, to be added to the right ascension of Venus previously found from the Sun, so that for this time the right ascension of Venus is $58^{\circ} 19' 6''$. From this is subtracted the parallax of ascension, and the remainder will be the apparent right ascension of Venus, $58^{\circ} 15' 17''$.

To this is joined the ascensional difference between Venus and the lower head of Gemini, investigated earlier, which gives the right ascension of the southern head of Gemini, $109^{\circ} 54' 28''$. But on account of the refraction that could insinuate itself at that altitude — when Venus was observed below the head of Gemini — let $0^{\circ} 0' 15''$ be added; and so its right ascension, once verified, will be $109^{\circ} 54' 43''$. From this, finally, when the ascensional difference between the bright star of Aries [Lucida Arietis] and the lower head of Gemini, sufficiently known from other observations — $83^{\circ} 57' 20''$ — is subtracted, there remains the right ascension of the bright star of Aries, $25^{\circ} 57' 23''$, which was sought. And so that this right ascension too may be carried over to the completed year of Christ 1585, for 3 years and 9 months I add the intermediate motion of $0^{\circ} 3' 7''$, and I find the right ascension of the bright star of Aries for the exact year stated, $26^{\circ} 0' 30''$ — which it was our intention to investigate.

In just this way, as already mentioned, I diligently investigated the right ascension of the fixed star derived in the year 1582, by employing several other experiments made at that time under the same heading. For beyond the hundreds of daytime observations of Venus relative to the Sun that I made in that same year during the spring — and which I then transferred by night to the stars — I selected only the three given above, lest the very abundance of material weary the reader. But since, as I also indicated before, a doubt might be raised as to whether the parallaxes and refractions applied here in particular were exactly correct, or whether through some defect in them, or through some excessive deviation, an error might have been committed; and since it therefore seemed advisable to verify the whole matter by yet another line of reasoning and to bring it out into the open free of any fear of error: for this purpose I also made

comparable considerations of Venus not only by evening observations but by morning ones as well. I obtained a great many of these in the following years, and from them I will here set out twelve at least — equally accurate and mutually consistent — as I shall now recount them in order.

[Section title]

Twelve further determinations of Venus, both at morning and at evening, comparing the Sun with the fixed stars in turn, so that the right ascension of the brighter star above the head of Aries may be established and confirmed more fully and more clearly, free of any hindrance from parallaxes or refractions, and free of any suspicion of error.

I.

From observations made in the year 1582 on 27 February and in the year 1585 on 21 September, with the Sun at an altitude of 10 degrees.

In the year 1582, on 27 February, at 4 hours 18 minutes in the afternoon, the distance between the Sun and Venus measured by the trigonal sextant was found to be $46^{\circ} 10\frac{1}{4}'$. The altitude of the Sun at that time was 10 degrees; the altitude of Venus, 45 degrees. The declination of Venus was $15^{\circ} 51'$ north. From our tables the place of the Sun was found to be $18^{\circ} 51' 22''$ of Pisces ♓, the right ascension of that place $349^{\circ} 45' 47''$, and its declination $4^{\circ} 25\frac{1}{2}'$ south.

Diagram. A spherical triangle constructed on the page. The apex A is at top; from A two arcs sweep down, one to the lower left and one to the lower right. The point C lies on the left arc; D is at lower left, E at lower right, and B at the bottom.

- A (apex): the pole of the equator
- B (bottom): the Sun
- C (left arc): Venus
- D (lower left), E (lower right): base points of the figure

Therefore, in this diagram — where A represents the pole of the equator, B the Sun, and C Venus — the triangle BAC has all three of its sides known. For BA is $94^{\circ} 25\frac{1}{2}'$ (the declination of the Sun added to a quadrant); CA is $74^{\circ} 9'$ (the complement of the declination of Venus); and BC is $46^{\circ} 10\frac{1}{4}'$, the observed distance.

Hence the angle BAC also became known: $41^{\circ} 55' 35''$. This is the arc of the equator comprised between the Sun and Venus, which, added to the right ascension of the Sun, yields the right ascension of Venus as $31^{\circ} 41' 22''$.

On the same day, at 6 hours 23 minutes in the afternoon, the distance between Venus and the eye of Taurus γ [Aldebaran] was found to be $30^{\circ} 6'$. The declination of Venus, taken by another instrument especially well suited to this task, was $15^{\circ} 53\frac{1}{2}'$ north. The altitude of Venus at that time was very nearly 33 degrees.

Now in the figure here assigned, let the side BA be $74^{\circ} 6\frac{1}{2}'$ (the complement of the declination of Venus to a quadrant); CA be $74^{\circ} 24'$ (the complement of the declination of the eye of Taurus γ [Aldebaran]); and BC be $30^{\circ} 6'$, the distance between Venus and the eye of Taurus. From this the angle BAC, found by computation, is $31^{\circ} 18' 0''$, which measures the difference in ascension between Venus and Aldebaran. The diurnal motion of Venus in ascension is 57 minutes; and so in 2 hours 5 minutes [the interval between the observations] there corresponds at the equator $4' 57''$. Therefore, by adding these to the right ascension of Venus found from the Sun, the right ascension of Venus for this time comes out as $31^{\circ} 46' 19''$; and to this, when the ascensional difference of Venus with respect to the eye of Taurus γ is added, the right ascension of Aldebaran will be $63^{\circ} 4' 19''$.

Diagram. A spherical triangle. The apex A is at top; arcs descend to B on the right and to a base running between D (lower left) and E (lower right). The point C lies on the lower left.

- A (apex): the pole of the equator
- B (right): Venus
- C (lower left): the eye of Taurus [Aldebaran]
- D (lower left), E (lower right): base points

And from this, by subtracting the ascensional difference up to the bright star of Aries γ , namely $37^{\circ} 3' 15''$, the right ascension of the bright star of Aries is known: $26^{\circ} 1' 4''$. For the 3 years and 10 months, however, one must add $3' 12''$, and we shall then have the right ascension of the bright star of Aries as $26^{\circ} 4' 16''$, corresponding to the completed year of Christ 1585 — a value that must be refined by the following comparison.

In the year 1585, on 21 September, at 7 hours 32 minutes in the morning, the equatorial distance between the Sun and Venus was observed by the great armillaries to be exactly $43^{\circ} 36\frac{1}{2}'$; and likewise the altitude of the Sun was 10

degrees. The place of the Sun was $7^{\circ} 47' 10''$ of Libra ♎ ; the right ascension was $187^{\circ} 8' 45''$. Subtracting from it the aforesaid equatorial distance, the right ascension of Venus comes out as $143^{\circ} 32' 15''$.

In the morning of the same day, at 5 hours 30 minutes after midnight, the distance between Venus and the southern head of Gemini ♊ was found to be $34^{\circ} 59\frac{1}{2}'$, and the declination of Venus was $12^{\circ} 59'$ north, its altitude being $30\frac{1}{2}$ degrees.

Therefore, in the next following figure, let B be the southern head of Gemini ♊ and C be Venus. All the sides of the triangle BAC are known. For BA is the complement of the declination of the southern head of Gemini ♊ , $61^{\circ} 3'$; the side CA is the

complement of the declination of Venus, $77^{\circ} 1'$; and the side BC, the distance between Venus and the lower head of Gemini ♊ , is $34^{\circ} 59\frac{1}{2}'$. From this the angle BAC comes out as $33^{\circ} 34' 0''$, which marks the difference of right ascension lying between the star of Venus and the head of Gemini ♊ .

Diagram. A spherical triangle. The apex A is at top; arcs descend, B lying on the right-hand arc, with the base running from D (lower left) to E (lower right) and C on the lower left.

- A (apex): the pole of the equator
- B (right): the southern head of Gemini [Venus side]
- C (lower left): Venus
- D (lower left), E (lower right): base points

The span of time between the two observations is 2 hours 2 minutes, to which there correspond, of Venus's diurnal equatorial motion of 56 minutes, $4' 45''$. Subtracting these from the right ascension of Venus found relative to the Sun, the right ascension of Venus appropriate to this time is known: $143^{\circ} 27' 30''$. Then, subtracting once more the arc of ascensional difference between Venus and the southern head of Gemini ♊ found earlier, the right ascension of this star [the head of Gemini] comes out as $109^{\circ} 53' 30''$. From this in turn, when the difference of ascension up to the bright star of Aries ♈ is subtracted, namely $83^{\circ} 57' 20''$, the right ascension of the bright star of Aries comes out as $25^{\circ} 56' 10''$. To this, for the 3 remaining months, $13''$ must be added, and we shall obtain the right ascension of the bright star of Aries ♈ as $25^{\circ} 56' 23''$, corresponding to the completed year 1585. But for the year 1582, from 27 February, the same right ascension had earlier been given as $26^{\circ} 4' 16''$, so that the difference between the two is $7' 53''$. Halved, this is $3' 56\frac{1}{2}''$; and when added to the smaller value or subtracted from

the larger, it yields the true and bounded right ascension of the bright star of Aries Υ as $26^{\circ} 0' 20''$. And it was precisely this — to investigate the matter by this method, taking no account of parallaxes or refractions, but letting them mutually correct one another in this way — that was the purpose proposed.

II.

The same, to be tested from an observation made in the year 1582 on 5 March, compared with one of the year 1585 on 14 September, at an altitude of the Sun of $5\frac{1}{2}$ degrees.

In the year 1582, on 5 March, at 5 hours 12 minutes in the afternoon, the Sun was distant from Venus by $45^{\circ} 51\frac{1}{2}'$. The altitude of the Sun at that time was $5\frac{1}{2}$ degrees; the elevation of Venus, 44 degrees. The declination of Venus was likewise north, $18^{\circ} 14\frac{1}{4}'$. The true place of the Sun was $24^{\circ} 51' 20''$ of Pisces ♊ ; its declination, $2^{\circ} 3' 3''$ south; its right ascension $355^{\circ} 16' 54''$ — all of this drawn from our tables. From this the right ascension of Venus was gathered by the following reasoning.

Let the side BA be $92^{\circ} 3'$ (the declination of the Sun added to a quadrant); CA be $71^{\circ} 45\frac{3}{4}'$ (the complement of the declination of Venus); and BC be $45^{\circ} 51\frac{1}{2}'$ (the distance between the Sun and Venus). Hence the angle BAC comes out as $41^{\circ} 47\frac{2}{3}'$, the difference of right ascension between the Sun and Venus, which, added to the given ascension of the Sun, produces the right ascension of Venus as $37^{\circ} 4' 44''$, appropriate to this time.

Diagram. A spherical triangle. The apex A is at top; arcs sweep down to a base from D (lower left) to E and B at the bottom right. The point C lies on the left arc.

- A (apex): the pole of the equator
- B (lower right): the Sun
- C (left arc): Venus
- D (lower left), E (lower right): base points

On the same day, at 7 hours 2 minutes in the afternoon, Venus was distant from the eye of Taurus ♉ [Aldebaran] by $24^{\circ} 48'$, measured by the sextant, at an altitude of Venus of 29 degrees. At the same time the declination of Venus was north, $18^{\circ} 16'$, and the declination of the eye of Taurus ♉ at the same time was north, $15^{\circ} 36'$. Hence the ascensional difference of the two is found in this way.

In the triangle BAC, the side BA is the complement of the declination of Venus, $71^{\circ} 44'$; CA, of the eye of Taurus ♉ , $74^{\circ} 24'$; and BC, the distance between them, $24^{\circ} 48'$.

Therefore the angle BAC is given as $25^{\circ} 47' 44''$, measuring the magnitude of the ascensional arc intercepted between Venus and the eye of Taurus γ .

Diagram. A spherical triangle. The apex A is at top; arcs descend, B on the right-hand arc, with the base running from D (lower left) to E (lower right) and C on the lower left.

- A (apex): the pole of the equator
- B (right): Venus
- C (lower left): the eye of Taurus [Aldebaran]
- D (lower left), E (lower right): base points

The diurnal motion of Venus with respect to the equator is 54 minutes; the interval of time between the two observations is 1 hour 50 minutes, to which there correspond in Venus's motion of ascension $4' 8''$; and these, added to the right ascension of Venus found earlier relative to the Sun, establish the right ascension of Venus, $37^{\circ} 8' 52''$, suited to this time. Now if to this ascension of Venus we add the difference of its ascension relative to Aldebaran found earlier, the right ascension of the eye of Taurus γ results: $62^{\circ} 56' 36''$. From this in turn, when the difference of ascension of the eye of Taurus γ up to the bright star of Aries γ is subtracted — which is $37^{\circ} 3' 15''$ — there will remain the right ascension of the bright star of Aries γ , $25^{\circ} 53' 21''$. So that this may correspond to the completed year 1585, one must add $3' 12''$; and thus, for that year, the right ascension of that star of Aries γ that is sought comes out as $25^{\circ} 56' 33''$ — a value, however, that must be bounded by the next following observation.

In the year 1585, on 14 September, at 6 hours 40 minutes in the morning, the equatorial distance between the Sun and Venus was found to be $43^{\circ} 48'$ by the great armillaries; likewise, the altitude of the Sun was $5\frac{1}{2}$ degrees, the altitude of Venus 38 degrees. For this time, the place of the Sun was found from our own canons to be $0^{\circ} 51' 23''$ of Libra ♎ ; the right ascension of Venus,

part $180^{\circ} 47' 7''$, and when the equatorial distance between the Sun and Venus found by the instrument is subtracted from this, the right ascension of Venus emerges as $136^{\circ} 59' 7''$.

But earlier, on the same day, at 5h 24m after midnight, by means of the same armillaries the ascensional difference of Venus and the eye of Taurus [Aldebaran] was detected as $73^{\circ} 48\frac{1}{4}'$. Now the interval of time by which this observation preceded the other, taken relative to the Sun, is 1h 16m; and to this, by the daily motion of the Sun reckoned along the equator, there correspond $2' 54''$. Subtracted from the right ascension of Venus found by way of the Sun, these

leave the right ascension for this time as $136^{\circ} 56' 13''$. From this in turn let the ascensional difference between Venus and the eye of Taurus be removed; the result is the right ascension of the eye of Taurus, $63^{\circ} 7' 43''$. When the ascensional difference between this star and the bright star of Aries is subtracted from it, the right ascension of the bright star of Aries comes out as $26^{\circ} 4' 28''$.

Then, adding for the $3\frac{1}{2}$ months an amount of $15''$ to reach the end of the completed year, the right ascension of this star for the year 1585 completed will be $26^{\circ} 4' 43''$. But for the year 1582, on 5 March, when likewise referred to the beginning of the year 1585, its right ascension had been found to be $25^{\circ} 56' 33''$. The comparison made shows that this falls short of the value found just now by $8' 10''$, which is to be ascribed to the fact that parallaxes and refractions were not taken into account. Half of this, $4' 5''$, when added to the smaller right ascension or subtracted from the larger, restores the verified right ascension of the bright star of Aries as $26^{\circ} 0' 38''$ — which is what we set out to investigate.

III.

From observations made in the year 1582 — on the same day, namely 5 March — and in the year 1585, on 15 September, to test the same result, at a solar altitude of 8° in both cases.

In the year 1582, on 5 March, at 4h 52m PM, the distance between the center of the Sun and Venus was observed by the trigonal sextant to be $45^{\circ} 53\frac{1}{2}'$, and by the armillaries the declination of Venus was found to be $18^{\circ} 14'$ north. The altitude of the Sun at that time was 8° , and that of Venus 46° . From these data, and with the position of the Sun known according to the proper restitution of its motion, we investigated the right ascension of Venus — without any account being taken of parallaxes or refractions — in the following way. The true place of the Sun was $24^{\circ} 50' 28''$ in Pisces [♊], its right ascension $355^{\circ} 16' 8''$, and its declination $2^{\circ} 3' 27''$ south, all drawn from our verified tables. Therefore, now that the declination of both the Sun and Venus and their distance from each other are known, the difference of right ascension was determined thus.

It is to be understood that in the figure that follows next, A is the pole of the equator, of which D E represents a portion; B is Venus, C the Sun. It is therefore evident that B E is the decl-

-ination of Venus, C E the declination of the Sun, and that the angle B A C measures the difference of right ascension of both. The triangle B A C therefore has all its sides given. For the side C A is $92^{\circ} 3\frac{1}{3}'$, the Sun's declination added to a

quadrant; the side B A is $71^{\circ} 46'$, the complement of the declination of Venus; and B C is $45^{\circ} 53\frac{1}{2}'$, the very distance between the Sun and Venus that was observed. Hence, by the doctrine of spherical triangles, the angle B A C is established as $41^{\circ} 49' 50''$. The equatorial distance of the Sun and Venus sought for, when added to the right ascension of the Sun, yields the right ascension of Venus as $37^{\circ} 5' 58''$.

Diagram. A spherical triangle for the Sun–Venus determination. An arc descends from a vertex at the top of the page to a curved base at the foot.

- A (apex): the pole of the equator
- C (left side, lower): the Sun
- D (bottom left): on the equatorial arc
- E (bottom, right of D): foot of the arc from A
- B (bottom, below E): Venus [the label is partly cut at the page foot; read under magnification]

On the same day, at 7h 12m PM, the distance between Venus and the heel of Gemini [Pollux] was noted as $48^{\circ} 52\frac{1}{2}'$. The declination of Venus was $18^{\circ} 16'$ north, known at the same moment by observation. The altitude of Venus at that time was 28° . The declination of the heel of Gemini is $22^{\circ} 38\frac{1}{4}'$ north; hence the difference of right ascension of the two was not hidden. For in this figure, in which B represents Venus and C the heel of Gemini, since all the sides of the triangle B A C are given — B A being $71^{\circ} 44'$, the complement of the declination of Venus; C A being $67^{\circ} 21\frac{1}{2}'$, the complement of the declination of the heel of Gemini; and B C being $48^{\circ} 52\frac{1}{2}'$, the distance of the two from each other — by triangular computation the angle B A C is established as $52^{\circ} 13' 0''$, which measures the equatorial arc between Venus and the heel of Gemini.

The interval of time of the observation between Venus and the Sun, and likewise of this between Venus and the heel of Gemini, was 2h 20m, to which there correspond, at the daily motion of Venus relative to the equator of $54'$, an amount of $5' 15''$. This, added to the right ascension of Venus investigated above by means of the Sun, yields for this latter moment the right ascension as $37^{\circ} 11' 13''$. When the difference of right ascension between Venus and the heel of Gemini, found just before, is joined to this, the right ascension of that same heel of Gemini comes out as $89^{\circ} 24' 13''$.

Diagram. A second spherical triangle of the same construction, with an arc from an apex at top to a curved base at the foot.

- A (apex): the pole of the equator

- C (left side, lower): Venus
- D (bottom left): on the equatorial arc
- B (bottom right): the heel of Gemini [Pollux]
- E (bottom, below B): foot of the arc

Now since we have proposed to reduce these to the bright star of Aries, by subtracting the ascensional difference between the bright star of Aries and the heel of Gemini — known from sure observations to be $63^{\circ} 28' 10''$ — we shall attain our wish. For there remains the right ascension of the bright star of Aries, $25^{\circ} 56' 3''$.

But again, so that this may be carried forward to the year of Christ 1585 completed, according to the proportion by which the fixed stars accomplish $51''$ in single years — corresponding to $10'$ in three years — there is to be added, for the year 1585 completed, $3' 12''$. And the right ascension of the bright star of Aries came out as $25^{\circ} 59' 15''$, which we aimed to investigate in this way, with no account taken of parallax or refraction. But this value, when set against the one found by the same procedure for the year 1585, ought to be compared, so that a truer determination, not liable to parallaxes and refractions, may be drawn out.

In the year 1585, on 15 September, at 6h 55m AM, the distance between the Sun and Venus was found to be $45^{\circ} 48\frac{1}{2}'$, and at the same time the declination of Venus was $13^{\circ} 59\frac{1}{2}'$ north. The altitude of the Sun was 8° , as before; the altitude of Venus was 41° , not differing much from that earlier one. The place of the Sun, taken from our own tables, was $1^{\circ} 50' 47''$ in Libra [♎]; its right ascension $181^{\circ} 41' 45''$; its declination $0^{\circ} 44' 10''$ south. Hence the right ascension of Venus was disclosed by this method.

In the figure set out, let B be the Sun, C Venus, A the pole of the equator; the rest is self-evident. The triangle B A C has all three of its sides given. For B A consists of the declination of the Sun — since it is southern, added to a quadrant — being $90^{\circ} 44\frac{1}{4}'$; C A is $76^{\circ} 0\frac{1}{2}'$, the complement of the declination of Venus; and B C is the very distance of the Sun and Venus, $45^{\circ} 48\frac{1}{2}'$. Therefore the angle B A C is determined as $43^{\circ} 48' 35''$. The difference of right ascension of the Sun and Venus, which subtracted from the right ascension of the Sun known above by its given place, leaves the right ascension of Venus as $137^{\circ} 53' 10''$.

But earlier, on the same day, at 5h 15m AM, the distance between Venus and the lower head of Gemini [Castor] was taken as $29^{\circ} 47\frac{1}{2}'$. The declination of Venus was $14^{\circ} 0\frac{1}{2}'$ north. The southern declination of the head of Gemini, well enough

known from other observations, is $28^{\circ} 57'$. The altitude that Venus then had was $29\frac{1}{2}^{\circ}$. For which reason I shall examine the figure set alongside.

Diagram. A spherical triangle for the Sun–Venus determination of 15 September 1585.

- A (apex, top): the pole of the equator
- C (right side): one of the two points (Sun / Venus)
- D (lower left): on the equatorial arc
- E (lower right): foot of the arc
- B (bottom left): the remaining point

Let A in this figure be the pole of the equator, C Venus, B the lower head of Gemini. Of the triangle B A C, the individual sides are known. For B A is $61^{\circ} 3'$; the complement of the declination of the lower head of Gemini, C A, is $75^{\circ} 59\frac{1}{2}'$; the complement of the declination of Venus, B C, is $29^{\circ} 47\frac{1}{2}'$, the distance of the two. Hence the angle at A is $27^{\circ} 51' 0''$, and the difference of right ascension between Venus and the lower head of Gemini will not be hidden.

And so that the right ascension of Venus, found earlier by means of the Sun, may hold good for this moment of time, let there be subtracted a proportional part of the daily motion of Venus — which relative to the equator is $54'$ — answering to 1h 40m, namely $3' 44''$; and the right ascension of Venus for this very time will be $137^{\circ} 49' 26''$. When the ascensional difference of that same star and of the lower head of Gemini, just now found, is subtracted from this, the right ascension of the head of Gemini comes out as $109^{\circ} 58' 26''$. If from this in turn is taken away the ascensional difference between the bright star of Aries and the lower head of Gemini — carefully determined elsewhere as $83^{\circ} 57' 20''$ — there will remain the right ascension of the bright star of Aries, $26^{\circ} 1' 6''$.

Diagram. A second spherical triangle of the same kind, an arc from an apex at top to a curved base at the foot.

- A (apex, top): the pole of the equator
- B (right side): Venus
- C (lower left): the lower head of Gemini [Castor]
- D (bottom left): on the equatorial arc
- E (bottom right): foot of the arc

added for the $3\frac{1}{2}$ months, so that the reduction may be made to the year 1585 completed, $15''$; and the right ascension of the bright star of Aries will come out as $26^{\circ} 1' 21''$.

Comparing this now with the value investigated above from the observations of the day of 5 March in the year 1582, which was found to be $25^{\circ} 59' 15''$, the difference of the two will be $2' 6''$, creeping in by reason of parallaxes and refractions. Half of this, $1' 3''$, added to the smaller right ascension of the bright star of Aries, or subtracted from the larger, shows the true right ascension of that star of Aries, $26^{\circ} 0' 18''$, freed from all obstacles, and applied to the year 1585 completed — which is what we were seeking.

III.

A comparison of the year 1582 and the day of 9 March with the year 1585, the 15th of September, at a solar altitude of 6° .

In the year 1582, on 9 March, at 5h 14m PM, the distance between the Sun and Venus was taken as $45^{\circ} 33'$. The altitude of the Sun at that time was 6° , and that of Venus 43° . The declination of Venus was $19^{\circ} 38\frac{1}{2}'$ north. The place of the Sun corresponding to this given time was $28^{\circ} 49' 14''$ in Pisces [♊]; the right ascension of the Sun $358^{\circ} 55' 5''$; and its declination $0^{\circ} 28\frac{1}{2}'$ south. From these the right ascension of Venus was disclosed thus.

Let A be the pole of the equator, B the Sun, C Venus. The triangle B A C has all three of its sides given. B A is $90^{\circ} 28\frac{1}{2}'$, the declination of the Sun added to 90° ; C A is $70^{\circ} 21\frac{1}{2}'$, the complement of the declination of Venus; B C is $45^{\circ} 33'$, the distance itself between the Sun and Venus. Therefore, by triangular computation, the angle B A C will not be hidden: $41^{\circ} 42' 38''$, which is the measure of the difference of right ascension of Venus and the Sun. Joined to the right ascension of the Sun, this yields the right ascension of Venus as $40^{\circ} 37' 43''$, now known.

Diagram. A spherical triangle for the Sun–Venus determination of 9 March 1582, an arc from an apex at top to a curved base at the foot.

- A (apex, top): the pole of the equator
- C (left side): one of the points (Sun / Venus)
- I (bottom left): on the equatorial arc
- E (bottom right): foot of the arc
- B (bottom, below E): the remaining point

On the same day, PM, at 7h 14m, between Venus and the eye of Taurus [Aldebaran] the interval was $21^{\circ} 37'$. There was also observed, by means of another instrument, the declination of Venus at that time, $19^{\circ} 40'$ north, at an altitude of the same of 30° . The declination of the eye of Taurus, well enough known beforehand, is $15^{\circ} 36'$ north.

For which reason, in the figure that follows next, let B be Venus, C Aldebaran. Of the triangle B A C, the individual sides are likewise known. For B A is the complement of the declination of that same star [Venus], $70^{\circ} 20'$; C A is the complement of the decl-

the declination of the eye of Taurus [Aldebaran], $74^{\circ} 24'$. The distance between Venus and Aldebaran is $21^{\circ} 37'$. Therefore the angle of the ascensional difference of both will not be concealed here either: the angle BAC is $22^{\circ} 17' 49''$.

Now the diurnal motion of the right ascension of Venus was $52'$. Accordingly, for the 2 hours 0 minutes that fell between the two observations, there correspond $4' 20''$. Adding these to the right ascension of Venus determined earlier, the right ascension of Venus at this time will be $40^{\circ} 42' 3''$. Combining this with the ascensional difference between Venus and the eye of Taurus, the right ascension of the eye of Taurus comes out as $62^{\circ} 59' 52''$. From this, subtracting the difference in ascension of the bright star of Aries from the same point, the right ascension of the bright star of Aries is left as $25^{\circ} 56' 37''$.

To this should be added the intervening motion for 3 years and 10 months, namely $3' 12''$. And so for the year 1585 the right ascension of the bright star of Aries will be $25^{\circ} 59' 49''$ — which is what was sought, so that a comparison may be made with what follows and a limit thereby established.

Diagram. A spherical triangle drawn as a curved-sided figure narrowing to a point at the top. Apex A at the top; a curved arc from A descends to B on the right side, where a shorter cross-arc (B to the region near C) is drawn. The base runs along the bottom from C (lower left) to E (lower right), with D marked just below and left of E.

- A (apex): vertex at the pole
- B (right, mid-lower): point on the descending arc
- C (lower left): base vertex
- D (lower left, below C): base point
- E (lower right): base vertex

In the year 1585, on 15 September, in the morning at 6 hours 48 minutes, the distance between the Sun and Venus was observed to be $45^{\circ} 48'$. The altitude of the Sun was 6° , as also above. The altitude of Venus was $40\frac{1}{2}^{\circ}$. The declination of Venus, by the armillae, was $13^{\circ} 59\frac{3}{4}'$ north. The place of the Sun was $1^{\circ} 50' 41''$ of Libra [$\underline{\alpha}$]. Its right ascension was $181^{\circ} 41' 28''$. Its declination was $0^{\circ} 44' 14''$ south.

Let there now be set in this figure B = Sun [$\odot$], C = Venus [♀], A = pole of the equator. In the triangle BAC, the side BA is $90^{\circ} 44\frac{1}{4}'$, known from the declination of the Sun added to a quadrant. The side CA is $76^{\circ} 0\frac{1}{4}'$, the complement of the declination of Venus. The side BC is $45^{\circ} 48'$, the distance from the Sun. Hence the angle BAC is $43^{\circ} 48' 9''$, representing the difference in right ascension between the Sun and Venus. Subtracted from the right ascension of the Sun, this leaves the right ascension of Venus as $137^{\circ} 53' 19''$.

But in the morning of the same day, at 5 hours 20 minutes, the separation between Venus and the meridional Head [the southern star of the Head of Aries, Υ II] was measured as $29^{\circ} 48'$. And the declination of Venus was $14^{\circ} 0\frac{1}{2}'$ north, at an altitude of 30° . So let it now be set in the following figure that B = Venus and C = the southern Head [♀ ... C = Head II]. The side BA is $61^{\circ} 3'$; the comple-

Diagram. A second curved-sided spherical triangle with apex A at the top. An arc descends from A to C on the right side; the base runs from D (lower left) to E (lower right), with B marked at the lower left below D, and two arcs crossing near the base.

- A (apex): pole vertex
- C (right, mid-lower): point on the descending arc
- D (lower left): base point
- E (lower right): base vertex
- B (lower left, below D): base point

[comple-]ment of the declination of the meridional Head [II]: CA is $75^{\circ} 59\frac{1}{2}'$. The complement of the declination of Venus, BC, is $29^{\circ} 48'$. The distance between Venus and the meridional Head [II], observed, gives the angle BAC as $27^{\circ} 51' 40''$, representing the ascensional difference between Venus and the lower Head [II].

The diurnal motion of Venus referred to the equator was $54'$. Therefore, for the interval of 1 hour 28 minutes, there correspond proportionally $3' 18''$. Subtracting this from the ascension of Venus found above from the Sun leaves the right ascension of Venus congruent with this time, $137^{\circ} 50' 1''$. And from this, removing

the ascensional difference of Venus from the lower Head [II], the right ascension of the lower Head [II] remains $109^{\circ} 58' 21''$.

The ascensional difference between the meridional Head [II] and the bright star of Aries [Υ] is found to be $83^{\circ} 57' 20''$; subtracting this leaves the known right ascension of the bright star of Aries, $26^{\circ} 1' 1''$. Adjoining now the $15''$ for the $3\frac{1}{2}$ months remaining to the end of the year, the right ascension of the bright star of Aries for the year 1585 complete will be $26^{\circ} 1' 16''$.

But in the year 1582, on 9 March, it had earlier been $25^{\circ} 59' 49''$; the difference between these is $1' 27''$. Half of this, $43\frac{1}{2}''$, added to the smaller, shows the true right ascension of the bright star of Aries to be $26^{\circ} 0' 32''$ — which is what we were seeking.

V.

To test this very same thing from the year 1586, the day 26 December, and from the year 1586, 15 December, at a solar altitude of 3° .

Diagram. A tall curved-sided spherical triangle with apex A at the top. An arc descends from A to B on the right side, where a cross-arc runs toward C; the base runs from C (lower left) to E (lower right), with D marked just below and left of C.

- A (apex): pole vertex
- B (right, mid-lower): point on the descending arc
- C (lower left): base vertex
- D (lower left, below C): base point
- E (lower right): base vertex

In the year 1586, on 26 December, in the afternoon at 3 hours 2 minutes, the distance between the Sun and Venus was $46^{\circ} 30'$. The declination of Venus was $11^{\circ} 15\frac{1}{2}'$ south. The altitude of the Sun was 3° ; that of Venus, 23° . The place of the Sun was $14^{\circ} 51' 53''$ of Capricorn [$\cap$]. Its right ascension was $286^{\circ} 8' 42''$. Its declination was $22^{\circ} 41\frac{1}{2}'$ south.

In this configuration, then, let A = the southern pole, B = Venus, C = Sun. The triangle BAC has its side BA given, $78^{\circ} 44\frac{1}{2}'$, the complement of the declination of Venus. CA is $67^{\circ} 18\frac{1}{6}'$, the complement of the declination of the Sun, also with respect to the southern pole. BC, the distance, is given as $46^{\circ} 30'$. Hence the angle BAC, produced by calculation, is

Diagram. A spherical triangle with vertices D (upper left) and E (upper right) along the top, B at the upper left below D, C on the right side, and apex A at the bottom point. The figure narrows downward to A.

- D (upper left): vertex
- E (upper right): vertex
- B (left, below D): point
- C (right): point on side
- A (bottom apex): pole vertex

[the angle is] $47^{\circ} 21' 5''$, which determines the difference in right ascension of the Sun and Venus; and so, by adding it to the right ascension of the Sun, the right ascension of Venus becomes known, $333^{\circ} 29' 47''$.

Then, after noon at 4 hours 49 minutes, the equatorial distance between Venus and the bright star of Aries [γ] was found to be $52^{\circ} 21'$. The altitude of Venus was $20\frac{1}{2}^{\circ}$. The interval of time by which this observation followed the other was 1 hour 27 minutes; to this, given the diurnal motion of Venus of $48'$, there correspond $4' 54''$. Adding these to the right ascension of Venus gives the right ascension agreeing with this time, $333^{\circ} 34' 41''$. If to this is added the equatorial distance between Venus and the bright star of Aries, the right ascension of the bright star of Aries results as $25^{\circ} 55' 41''$. From this, subtracting $50''$ for about one year, its right ascension is left as $25^{\circ} 54' 51''$, measured to the year of Christ 1585 — which we shall render more exactly by what follows.

In the year 1588, on 15 December, in the morning at 9 hours 6 minutes, Venus was distant from the Sun $46^{\circ} 36'$. The altitude of the Sun was 3° . The elevation of Venus was 20° . The declination of the same was $14^{\circ} 4'$ south. The place of the Sun was $3^{\circ} 53'$ of Capricorn [$\cap$]. Its right ascension was $274^{\circ} 14' 49''$. Its declination was $23^{\circ} 28' 2''$ south.

So, in the noted configuration, let A = the southern pole, B = Venus, C = Sun. The side BA is $75^{\circ} 56'$, the complement of the declination of Venus with respect to the southern pole. CA is $66^{\circ} 32'$, the complement of the declination of the Sun. BC, the distance between the two, is $46^{\circ} 30'$. Hence the angle BAC could not lie hidden: $48^{\circ} 26' 18''$ — namely the ascensional difference between Venus and the Sun. Subtracting this from the right ascension of the Sun leaves the right ascension of Venus, $225^{\circ} 48' 31''$.

On the same day, in the morning at 7 hours 41 minutes, the distance between Venus and Spica of Virgo [♍, Spica ♍] was $29^{\circ} 33\frac{1}{2}'$. The declination of Venus was $14^{\circ} 2'$ south, by the armillae. The altitude of this [star] was 19° .

Diagram. A curved-sided spherical triangle with vertices D (upper left) and E (upper right) along the top, B at the upper left below D, C on the right side, and apex A at the bottom point.

- D (upper left): vertex
- E (upper right): vertex
- B (left, below D): point
- C (right): point on side
- A (bottom apex): pole vertex

To investigate from this the ascensional interval between Venus and Spica of Virgo, let us use the same figure, in which B = Spica [♍] and C = Venus. Hence, in the triangle BAC, the side BA is $81^{\circ} 23\frac{3}{4}'$, the complement of the declination of Spica [♍] with respect to the southern pole. CA is $75^{\circ} 58'$, the complement of the declination of Venus with respect to the same pole. BC is $29^{\circ} 33\frac{1}{2}'$, the distance between Venus and Spica. Given these, by the aid of the doctrine of triangles, the angle BAC is disclosed as $29^{\circ} 44' 21''$, which shows the ascensional difference between Venus and Spica. The interval of time by which this observation was earlier than the other is 1 hour 25 minutes; to this, given the diurnal motion of Venus of $1^{\circ} 4'$, [there correspond] with respect to the equa-

[with respect to the] equator there correspond $3' 47''$, to be subtracted from the right ascension of Venus previously found from the Sun, so that it may agree with this time: $225^{\circ} 44' 44''$. From this, subtracting the ascensional difference between Venus and Spica [♍], the remainder gives the right ascension of Spica, $196^{\circ} 0' 23\frac{3}{4}'$. From this, again subtracting the ascensional difference between the bright star of Aries [♈] and Spica [♍] — fairly constant at $169^{\circ} 51' 25''$ — there would remain the right ascension of the bright star of Aries, $26^{\circ} 8' 58''$. For 2 years and 11 months, subtract $2' 26''$; the remainder will be the right ascension of the same for the year 1585 complete, $26^{\circ} 6' 32''$.

But because, in the year 1586, on the day 26 December, the same was found to be $25^{\circ} 54' 51''$, the difference between the two turns out to be $11' 41''$. Half of this, $5' 50\frac{1}{2}''$, added to the smaller, produces the right ascension of the bright star of Aries, corrected by setting a limit, as $26^{\circ} 0' 41\frac{1}{4}''$.

Indeed, here too it is evident that the difference in the right ascensions of the two over the various years is somewhat greater on this account — though not as much as before — because here likewise everything was carried out below the equator, in a more inclined position.

VI.

To explore the same, from the year 1586 by the day 27 December and the year 1588, 29 November, at an altitude in both cases of the Sun of $3\frac{1}{2}^{\circ}$.

In the year of the Lord 1586, on the day 27 December, in the afternoon at 2 hours 48 minutes, Venus was distant from the center of the Sun $46^{\circ} 22'$. The altitude of the Sun was $3\frac{1}{2}^{\circ}$; that of Venus, 23° . The southern declination of Venus was $10^{\circ} 49\frac{1}{2}'$. The place of the Sun was $15^{\circ} 52' 34''$ of Capricorn [♑]. Its right ascension was $287^{\circ} 14' 1''$. The southern declination of that place of the Sun was $22^{\circ} 34' 37''$.

Therefore, so that the difference in right ascension between the Sun and Venus may be known from these data, let there be in this figure A = the southern pole of the equator, B = Venus, C = Sun. The rest are self-evident.

Diagram. A curved-sided spherical triangle with vertices D (upper left) and E (upper right) along the top, B at the upper left below D, C on the right side, and apex A at the bottom point.

- D (upper left): vertex
- E (upper right): vertex
- B (left, below D): point
- C (right): point on side
- A (bottom apex): pole vertex

In the triangle BAC, then, since the side BA is the complement of the declination of Venus, $79^{\circ} 10\frac{1}{4}'$; the side CA, the complement of the declination of the Sun, $67^{\circ} 25\frac{1}{3}'$, with respect to the southern pole; and BC, the distance between the two, $46^{\circ} 22'$ — therefore the angle BAC was given, $47^{\circ} 3' 6''$, which is the difference in right ascension of the Sun and Venus. This, added to the right ascension of the Sun, establishes the right ascension of Venus, $334^{\circ} 17' 7''$.

On the same day, in the afternoon at 4 hours 48 minutes, the equatorial distance between Venus and the bright star of Aries [♈] was 51° ...

by means of the armillaries the value $51^{\circ} 0' 32''$ was obtained. Venus's altitude at that time was then $1^{\circ} 20' [?]$, and its diurnal motion with respect to the equator

was 0' 49". The time elapsed between this observation and another taken from the Sun was 2 hours 0 minutes, to which there corresponds, by the diurnal motion, 0' 4" 5". Adding these to Venus's right ascension previously found from the Sun — 334° 21' 12" — gives Venus's right ascension at this time. To this in turn is added the equatorial distance between Venus and the bright star, namely 25° 53' 12", yielding the right ascension of the bright star of Aries [Lucida ♈]: 25° 25' 53" [?] 12". For very nearly a single year about 0' 50" must be subtracted, and the result will be a right ascension of 25° 52' 22", the value for the completed year 1585, which we shall compare with the one that follows.

In the year 1588, on 29 November, in the morning at 9 hours 11 minutes, the elongation of the Sun and Venus was 46° 0' 38". The Sun's altitude was 3½°, that of Venus 24½°. Venus's declination was 9° 16' south. The place of the Sun at that time was Sagittarius 17° 33' 8". The right ascension was 256° 27' 48". The declination was 22° 56½' south. So that the right ascension between the Sun and Venus may here be investigated, let it be inquired in this way.

Let in this figure C be the Sun, B Venus, A the south pole. The side BA is the complement of Venus's declination, 80° 44'. The side CA is the complement of the Sun's declination, 67° 3½'. The side BC is the observed distance between the Sun and Venus, 46° 38'. With these given, the angle BAC will not lie hidden: it is 46° 38' 55", which subtracted from the Sun's right ascension leaves Venus's right ascension, 209° 48' 53".

But on that same day, in the forenoon at 7 hours 11 minutes, the distance of Venus and Spica Virginis was 13° 31½', measured by the sextant. Venus's declination was 9° 13½' south. The declination of Spica Virginis [Spica ♍] was 8° 57¼' south. Venus's altitude at that time was 21½°. From this the difference in right ascension between Venus and Spica Virginis can be found, using the same figure in which B represents Venus and C represents Spica Virginis. For the side BA is the complement of Venus's declination to the south pole, 80° 46½'; CA is 81° 2¾'; the complement of the declination of Spica Virginis to the same pole; BC, the distance between the two, is 13° 31½'. Therefore, from the triangular computation the angle BAC comes out as 13° 41½', which measures the difference in right ascension between Venus and Spica Virginis. Venus's diurnal motion of right ascension is 56'. To 2 hours 0 minutes there therefore corresponds 0' 4" 40", to be subtracted from Venus's right ascension found above from the Sun; and so Venus's right ascension at this time is 209° 44' 13". If from this is taken the difference of right ascension of Spica Virginis and Venus, there remains the right ascension of Spica, 196° 2' 43". If from this in turn is subtracted the difference of

right ascension between the bright star of Aries [Lucida Υ] and Spica, known from other observations, namely $169^{\circ} 51' 25''$, there remains the right ascension of the bright star above the head of Aries [Lucida supra Caput Υ]: $26^{\circ} 11' 18''$.

Diagram. A spherical triangle resembling an elongated shield or pointed leaf, with the apex A at the bottom (the south pole) and a curved cross-arc near the top connecting C (left) and B (right). Two further points D (upper left) and E (upper right) sit above the cross-arc.

- A (bottom apex): the south pole [Polus Australis]
- B (right, on cross-arc): Venus
- C (left, on cross-arc): the Sun (in the first computation) / Spica Virginis (in the second)
- D (upper left): endpoint of an arc (unlabelled meridian endpoint)
- E (upper right): endpoint of an arc (unlabelled meridian endpoint)

In order to reduce this to the completed year 1585, for the span of two years and eleven months subtract $0^{\circ} 2' 26'''$, and there will remain $26^{\circ} 8' 52''$. But since, from 27 September in the year 1586, its ascension carried back to the same year 1585 was previously $25^{\circ} 52' 22''$, when the comparison is made the difference of the two will be $16' 30''$; half of this, $8'' 15'''$, joined to the smaller right ascension, yields the right ascension of the bright star of Aries [Lucida Υ] as $26^{\circ} 0' 37''$, quite precisely, just as we have undertaken to do. Now the reason this difference between the two right ascensions came out so plainly was that everything was arranged in a lower position, below the equator toward the horizon, and therefore more subject to refractions — which, however, were corrected by the limitation made in turn for that case.

VII.

To investigate the same by means of the determination made in the year 1587 on 9 January, and in the year 1588 on 6 December, at a solar altitude of 8 degrees.

In the year 1587, on 9 January, in the afternoon at 2 hours 21 minutes, the elongation of the Sun and Venus was $43^{\circ} 51\frac{1}{2}'$. The altitude of the Sun was 8° , that of Venus 28° . Venus's declination was $5^{\circ} 13\frac{1}{2}'$ south. The place of the Sun, from its own restitution, was in $29^{\circ} 7' 26\frac{7}{8}''$. The right ascension of this place was $301^{\circ} 17' 5''$. The declination of the same was $20^{\circ} 24\frac{1}{2}'$ south. From this, taken together with Venus's declination and its given distance from the Sun, the ascensional difference became known in the following way.

Let in this figure A be the south pole, B Venus, C the Sun. In the triangle BAC, since the sides are given of whatever length — for CA is the complement of the Sun's declination to the south pole, $69^{\circ} 35\frac{1}{2}'$; BA the complement of Venus's declination, $84^{\circ} 46\frac{1}{2}'$; the side BC the distance between the two, the Sun and Venus, $43^{\circ} 51\frac{1}{2}'$ — therefore the triangular computation revealed the angle BAC to be $42^{\circ} 23' 38''$, which gives the equatorial distance between the Sun and Venus. If you add this to the Sun's right ascension previously found, Venus's right ascension comes out as $343^{\circ} 40' 43''$, which was the first thing to be sought.

Afterward, in the afternoon at 5 hours 40 minutes, Venus was distant from the often-mentioned bright star of Aries [Lucida ♈] by $49^{\circ} 14\frac{1}{4}'$. Venus's declination was then $5^{\circ} 8\frac{1}{2}'$ south. Its altitude was 20° . Therefore, since the declination of the bright star of Aries [Lucida ♈] is also known, namely $21^{\circ} 28\frac{1}{2}'$, the ascensional difference cannot lie hidden.

Diagram. A spherical triangle in the form of an elongated pointed shield, apex A at the bottom (the south pole) and a curved cross-arc near the top connecting C (right) and B (left). Points D (upper left) and E (upper right) sit above the cross-arc.

- A (bottom apex): the south pole [Polus Australis]
- B (left, on cross-arc): Venus
- C (right, on cross-arc): the Sun
- D (upper left): unlabelled arc endpoint
- E (upper right): unlabelled arc endpoint

For in the triangle ABC, from the given sides — BA, $95^{\circ} 8\frac{1}{2}'$ (because Venus's declination is added to the quadrant, since its declination is southern); CA, $68^{\circ} 31\frac{1}{2}'$ (the complement of the declination of the bright star of Aries [Lucida ♈]); and BC, $49^{\circ} 14\frac{1}{2}'$, which represents the distance — by the found triangles the angle BAC is $42^{\circ} 16' 34''$, measuring the difference of right ascension between Venus and the bright star of Aries [Lucida ♈]. The interval of time between this observation of Venus and the other made from the Sun was 3 hours 19 minutes, to which, the diurnal motion of Venus with respect to the equator being $0' 41''$, there correspond proportionally $0' 5'' 39'''$; and when these are joined to Venus's right ascension found from the Sun, there comes out the right ascension of Venus appropriate to this time, $343^{\circ} 46' 22''$. Let there be added to this the difference of its right ascension from the bright star of Aries [Lucida ♈] previously inquired into, and there comes out the right ascension of the bright star of Aries [Lucida ♈], $26^{\circ} 2' 56''$. To reduce this to the completed year 1585, subtract $0' 51''$ from it for

one year, and there remains a right ascension of $26^{\circ} 2' 5''$, the value answering to the said completed year.

In the year 1588, on 6 December, in the morning at 10 hours 30 minutes, the distance between the Sun and Venus was $46^{\circ} 57\frac{1}{2}'$. The Sun's altitude was 8° , that of Venus $19\frac{1}{4}^{\circ}$. The declination of the same was $11^{\circ} 21\frac{1}{2}'$ south. The place of the Sun was $24^{\circ} 45' 23''$ Sagittarius. The right ascension was $264^{\circ} 17' 0''$. The declination was $23^{\circ} 24\frac{1}{4}'$ south. From the given distance of Venus from the Sun, and the declination of each now known, the ascensional difference came to light in this way.

Let in this figure A be the south pole, B Venus, C the Sun. DE is the portion of the equator to which through the places of the Sun and Venus the quadrants of the circle DA and DE [recte: EA] are drawn from the south pole. Now in the triangle BAC, since the side BA is the complement of Venus's declination to the south pole, $78^{\circ} 38\frac{1}{2}'$; CA is the complement of the Sun's declination to the same southern pole, $66^{\circ} 34\frac{3}{4}'$; BC is the very distance between the Sun and Venus, observed as $46^{\circ} 57\frac{1}{2}'$ — therefore, these three sides being known, the angle BAC was found by computation according to the laws of triangles to be $47^{\circ} 48' 20''$, which measures the arc on the equator between the Sun and Venus there enclosed. If this is subtracted from the Sun's right ascension, it leaves Venus's right ascension as $216^{\circ} 28' 40''$.

Diagram. A narrow, elongated spherical triangle, apex A at the bottom (the south pole), with a curved cross-arc near the top connecting C (left) and B (right). Points D (upper left) and E (upper right) mark the equatorial arc above.

- A (bottom apex): the south pole [Polus Australis]
- B (right, on cross-arc): Venus
- C (left, on cross-arc): the Sun
- D (upper left): endpoint of the equatorial portion DE
- E (upper right): endpoint of the equatorial portion DE

And when on the same day, in the morning at 7 hours 28 minutes, Venus was observed to have moved away from Spica Virginis [Spica ♍] by $20^{\circ} 17\frac{1}{2}'$, at which time the altitude of Venus was also $20\frac{1}{2}^{\circ}$ — when its declination too was $11^{\circ} 18'$ south. The declination of Spica Virginis [Spica ♍], from observations by no means deceptive, stood in the same year at $8^{\circ} 57\frac{1}{4}'$ south. Therefore, with these given, the ascensional difference between Venus and Spica Virginis will easily appear.

In this figure A will represent the south pole, B Spica Virginis [Spica ♍], C Venus. Since therefore the triangle BAC has all its sides known — BA, $81^{\circ} 2\frac{3}{4}'$; the complement of the declination of Spica Virginis [Spica ♍], CA, $78^{\circ} 42'$; the complement of Venus's declination, BC, $20^{\circ} 17\frac{1}{2}'$, from the very distance between Venus and Spica Virginis — therefore the angle BAC, of the difference of right ascension between Spica and Venus, $20^{\circ} 28' 30''$, could not lie hidden. But the interval of time between this observation of Venus and the other made from the Sun was 3 hours 2 minutes. The diurnal motion of Venus with respect to the equator is $59\frac{1}{2}'$, to which proportionally corresponds, for the said interval of time, $0' 7'' 30'''$; and if this is subtracted from the right ascension of Venus investigated above from the Sun, there will remain the right ascension at the time when Venus was observed from Spica Virginis [Spica ♍], $216^{\circ} 21' 10''$. From this, the ascensional difference of Venus and Spica being again removed, the residual is the right ascension of Spica Virginis [Spica ♍], $195^{\circ} 52' 40''$.

Diagram. A narrow, elongated spherical triangle, apex A at the bottom (the south pole), with a curved cross-arc near the top connecting C (left) and B (right). Points D (upper left) and E (upper right) sit above the arc.

- A (bottom apex): the south pole [Polus Australis]
- B (right, on cross-arc): Spica Virginis
- C (left, on cross-arc): Venus
- D (upper left): unlabelled arc endpoint
- E (upper right): unlabelled arc endpoint

But since, as has been done in the preceding cases, this right ascension must be carried over to the bright star of Aries [Lucida ♈], let the intervening difference of right ascension between Spica and the bright star of Aries [Lucida ♈] — confirmed from other reliable observations — namely $169^{\circ} 51' 25''$, be subtracted, and there comes out the right ascension of the bright star of Aries [Lucida ♈], $26^{\circ} 1' 15''$.

Moreover, since this must be accommodated to the completed year 1585, let $0' 2'' 26'''$ be taken away for the space of 2 years and 11 months, and there will come out, for the said completed year, the right ascension of that star above the head of Aries [Lucida supra Caput ♈]: $25^{\circ} 58' 49''$. But when the value derived above for the year 1587, from 9 January, applied to the same completed year 1585, was found to be $26^{\circ} 2' 5''$, differing from this last by $0' 3'' 16'''$ — the half of which is $0' 1'' 38'''$ — this, joined to the smaller right ascension, produces the verified right

ascension of the bright star of Aries [Lucida Υ] as $26^{\circ} 0' 27''$, which is what we wished to demonstrate.

VIII.

To explore the same from the determination of the year 1587, on 24 January, and of the year 1588, on 26 October, at a solar altitude of $17\frac{1}{2}$ degrees.

In the year 1587, on 24 January, in the afternoon at 0 hours 15 minutes, the distance of the Sun and Venus was found to be $37^{\circ} 53\frac{3}{4}'$, the altitude of the Sun being $17\frac{1}{2}^{\circ}$, that of Venus 30° . At that time the...

the declination of Venus from this observation was $0^{\circ} 25'$ north, the place of the Sun $14^{\circ} 17' \approx$ [Aquarius], its right ascension $316^{\circ} 46' 14''$, and the declination of the same $16^{\circ} 36\frac{1}{3}'$ south — which in this figure the side BE represents, B being the Sun and C Venus. The side BA, $106^{\circ} 36\frac{1}{3}'$, is obtained by adding the Sun's declination to 90° . The side CA is $89^{\circ} 35'$, the complement of Venus's declination. The side BC is $37^{\circ} 53\frac{3}{4}'$, the distance between the Sun and Venus. Since here too the three sides of triangle ABC are known, the angle BAC will not be unknown: it is $33^{\circ} 26' 5''$. Since this determines the ascensional difference of the Sun and Venus, when it is added to the Sun's right ascension, the right ascension of Venus comes out as $350^{\circ} 12' 19''$.

Diagram. A narrow lens-shaped (almond/vesica) figure with apex A at the top. Near the base, the lower region is divided by curved arcs into the points C, D, E and B.

- A (apex, top): vertex A
- C (left, just above base): point C
- D (lower left): point D
- E (lower right): point E
- B (bottom right): point B

On the same day, in the afternoon at 5h 15m, Venus was distant from the bright star of Aries [Lucida Υ , the star above the head of Aries] by $40^{\circ} 46\frac{1}{6}'$, according to the observation, when Venus was at altitude $23\frac{1}{2}^{\circ}$. Its declination at the same time was observed to be $0^{\circ} 29\frac{1}{2}'$ north, while that of the bright star of Aries was $21^{\circ} 28\frac{1}{2}'$ north. Therefore, to find the ascensional difference of the two, proceed as follows.

In this assigned figure, let B be Venus and C the bright star of Aries. The side BA is $89^{\circ} 30\frac{1}{2}'$, the complement of Venus's declination. The side CA is $68^{\circ} 31\frac{1}{2}'$, the

complement of the bright star of Aries's declination. The side BC is $40^{\circ} 46\frac{1}{6}'$, the distance between the two. Hence, by the benefit of the triangle, the angle BAC came out as $39^{\circ} 51' 0''$, which measures the ascensional difference between Venus and the bright star of Aries. The interval of time elapsed between the two observations was 5h 0m. Venus's daily motion with respect to the equator is $20\frac{1}{2}'$; for this interval of time there correspond $4' 20''$. When these are added to the right ascension of Venus found from the Sun, the right ascension of Venus for this later moment is produced as $350^{\circ} 16' 39''$. If we now add to this the ascensional difference between it and the bright star of Aries, the right ascension of the bright star of Aries comes out as $26^{\circ} 7' 39''$, from which $55''$ is to be subtracted for 1 year and 1 month, so that for the year 1585 the sought right ascension of the bright star of Aries is $26^{\circ} 6' 44''$.

Now let us turn to the morning observations, from which the correction of the same is to be set up.

Diagram. A second lens-shaped figure with apex A at the top. The lower region is crossed by curved arcs marking points C, B, D and E.

- A (apex, top): vertex A
- C (left, lower): point C
- B (right, lower): point B
- D (bottom left): point D
- E (bottom right): point E

In the year 1588, on 26 September, in the morning at 11h 48m, the distance...

between the Sun and Venus was found to be $37^{\circ} 1\frac{3}{4}'$ by the trigonic sextant, when the Sun was at altitude $17\frac{1}{2}^{\circ}$ and Venus at altitude 25° . Its [Venus's] declination was $3^{\circ} 36\frac{1}{4}'$ south. The place of the Sun was $13^{\circ} 9' 19''$ ♍ [Virgo]. The Sun's right ascension was $220^{\circ} 41' 5''$, and the declination of the same was $15^{\circ} 50\frac{1}{2}'$ south. Let it be set up, then, in this figure: A the south pole, B Venus, C the Sun. The triangle ABC has all its sides given. For BA is $86^{\circ} 23\frac{3}{4}'$, the complement of Venus's declination relative to the south pole; CA is $74^{\circ} 9\frac{1}{2}'$, the complement of the Sun's declination relative to the same; and BC is $37^{\circ} 1\frac{3}{4}'$, the distance between the Sun and Venus. Therefore the side could not fail to determine the angle BAC, $35^{\circ} 32' 55''$, which determines the arc of the equator intercepted between the Sun and Venus. Subtracted from the Sun's right ascension, it leaves the right ascension of Venus, $185^{\circ} 8' 10''$.

Diagram. A figure with the top side DE running across the top and the curved base tapering downward to apex A. An arc CB crosses the upper portion.

- D (top left): point D
- E (top right): point E
- C (left): point C
- B (right): point B
- A (apex, bottom): vertex A

On the next following day, 27 October, in the morning at 6h 38m, Venus was distant from Cor Leonis [Regulus, "the Heart of Leo," ♌] by $42^{\circ} 24\frac{3}{4}'$. Its declination at that time was observed to be $3^{\circ} 34\frac{1}{2}'$ south. Its altitude was 20° . Since the declination of Cor Leonis was $13^{\circ} 57\frac{1}{2}'$ north — as is known from other observations made in the same...

...year — the ascensional difference between Venus and Cor Leonis was therefore investigated in this way.

Let B be Cor Leonis in the figure set beside this, C Venus, A the north pole. The side BA is $76^{\circ} 2\frac{2}{3}'$, the complement of the declination of Cor Leonis. CA is $93^{\circ} 34\frac{1}{2}'$, obtained by adding Venus's declination to a quadrant. BC is $42^{\circ} 24\frac{3}{4}'$, the distance between Venus and Regulus. From these three known sides the angle BAC was found, $38^{\circ} 56' 30''$, which determines the magnitude of the arc intercepted between Venus and Cor Leonis along the equator.

Diagram. A lens-shaped figure with apex A at the top; the lower region is crossed by curved arcs marking points B, E, D and C.

- A (apex, top): vertex A
- B (right): point B
- E (lower left): point E
- D (lower right): point D
- C (bottom left): point C

The daily motion of Venus in right ascension from day 26 to 27 October was $22'$. Of this, for the 18h 50m elapsed between the two observations there corresponds an intermediate motion of $17' 35''$, which, added to the right ascension of Venus found from the Sun on day 26, brings it forward to 6h 38m on 27 October — the right ascension of Venus when Cor Leonis was observed from it being $185^{\circ} 25' 25''$. From this, with the angle of ascensional difference between Venus and Cor Leonis subtracted, there remains the right ascension of Regulus, $146^{\circ} 28' 55''$. But

the difference in right ascension between it [Regulus] and the bright star of Aries has been explored earlier, $120^{\circ} 31' 20''$. Let this therefore be taken away from the right ascension of Cor Leonis found, and the remainder will be the right ascension of the bright star of Aries, $25^{\circ} 56' 35''$, on the assumption of the year and month. Since this is to be reduced to the completed year 1585, for a...

span of 2 years 16 months [recte: the printed text reads "Annorum 2. Mens. 16." — 2 years 16 months, evidently a slip], subtract $2' 22''$, and the right ascension of the bright star of Aries for that time is produced, $25^{\circ} 54' 13''$. But as above, from the observation of 24 January in the year 1587, its right ascension was found to be $26^{\circ} 6' 44''$. From this, the other being subtracted (since it is smaller), the difference of the two becomes $12' 31''$, whose half, $6' 15\frac{1}{2}'$, taken from the larger or added to the smaller right ascension of the bright star of Aries, yields its ascension as $26^{\circ} 0' 28\frac{1}{2}'$, very precisely verified for the proposed year, just as we determined was to be done.

IX.

To confirm nearly the same from the observation of the year 1587, on 16 August, and of the year 1588, on 16 April, at the altitude of the Sun, the same in 3 degrees.

In the year 1587, on 17 August, in the morning at 5h 13m, the distance between the Sun and Venus was taken in the heavens, $28^{\circ} 9'$. The altitude of the Sun was then $2\frac{2}{5}^{\circ}$ [recte: see note], the altitude of Venus $25\frac{1}{5}^{\circ}$ [numeral: ?]. The declination of Venus, found by the armillaries, was $19^{\circ} 26\frac{1}{2}'$ north. The place of the Sun was $3^{\circ} 2' 8''$ ♍ [Virgo]. The right ascension of the place was $154^{\circ} 59' 34''$. The declination was $10^{\circ} 25' 38''$ north. Hence the right ascension of Venus was found in this way, and it was not difficult.

Let A in this figure be the north pole [Polus aequatori], B the Sun, C Venus. The side BA is $70^{\circ} 33\frac{1}{2}'$. The side CA is $79^{\circ} 34\frac{1}{2}'$, the complement of the Sun's declination. BC is $28^{\circ} 9'$, the distance between the Sun and Venus. Therefore, by carrying out the calculation, the angle BAC comes out, $27^{\circ} 39' 6''$, which, since it is the ascensional difference itself between the Sun and Venus, when taken from the Sun's right ascension gives the right ascension of Venus, $127^{\circ} 20' 28''$.

Diagram. A lens-shaped figure with apex A at the top. Near the base, curved arcs cross, marking points C, B, D and E.

- A (apex, top): vertex A
- C (left): point C
- B (right): point B

- D (bottom left): point D
- E (bottom right): point E

On the same day, in the morning at 3h 37m, the distance between Venus and the upper star of Gemini [superius Caput Π , the upper Head of the Twins] was found to be $22^{\circ} 19\frac{3}{4}'$. The declination of Venus, by the armillaries, was $19^{\circ} 29\frac{3}{4}'$. The altitude of Venus was 13° . The declination of the upper Head of Gemini, from sure observations in that year, was $32^{\circ} 42\frac{1}{8}'$. Hence the ascensional difference of the two became known in this way.

This preceding figure can also be adapted to this task, so that C is Venus, B the upper Head of Gemini. In triangle BAC, then: since BA is the complement of the declination of the upper Head of Gemini, $57^{\circ} 17\frac{5}{8}'$; CA is $70^{\circ} 30\frac{1}{4}'$, the complement of Venus's declination relative to a quadrant of the circle; and BC is $22^{\circ} 19\frac{3}{4}'$, the observed distance. The angle BAC is therefore found, $20^{\circ} 8\frac{3}{4}'$, which exhibits the magnitude of the ascensional difference between Venus and the upper Head of Gemini. The daily motion of Venus along the equator is $1^{\circ} 14'$; therefore for 1h 36m there correspond $4' 56''$, which, taken from the right ascension of Venus found above from the Sun...

constitute the right ascension of Venus, $127^{\circ} 15' 32''$. Hence, by subtraction of Venus's ascensional difference from the right ascension of the upper Head of Gemini found earlier, there remains the right ascension of the same star [Venus], $107^{\circ} 6' 47''$. The difference in right ascension between the bright star of Aries and the upper Head of Gemini, known from sure observations, is $80^{\circ} 59\frac{3}{4}'$; let this be taken from the right ascension of the upper Head of Gemini, and the residual right ascension of the bright star of Aries will be $26^{\circ} 7' 2''$. But for 1 year $7\frac{1}{2}$ months let $1' 22''$ be subtracted, and we shall obtain, for the completed year of Christ 1585, the sought right ascension of the bright star of Aries, $26^{\circ} 5' 40''$ — yet to be limited in the following way.

In the year 1588, on 16 April, in the afternoon at 7h, the distance between the Sun and Venus was observed, $30^{\circ} 47'$. And the declination of Venus, then by the armillaries, was $22^{\circ} 46\frac{1}{2}'$ north. The altitude of the Sun here too was $2\frac{2}{5}^{\circ}$. The altitude of Venus was $27\frac{1}{2}^{\circ}$. The place of the Sun was $6^{\circ} 36' 22'' \propto$ [Taurus]. The right ascension of the place was $34^{\circ} 15' 30''$. The declination was $13^{\circ} 46\frac{1}{4}'$ north.

Diagram. A lens-shaped figure with apex A at the top. Near the base, curved arcs cross, marking points C, B, D and E.

- A (apex, top): vertex A
- C (left): point C

- B (right): point B
- D (bottom left): point D
- E (bottom right): point E

Let it be set up, then, in this assigned figure: A the north pole [Polus aequatoris], B the Sun, C Venus, in triangle BAC. The side BA is $76^{\circ} 13\frac{3}{4}'$. The side CA is $67^{\circ} 13\frac{1}{2}'$, the complement of the Sun's declination. The side BC is $30^{\circ} 47'$, the distance between the Sun and Venus. Hence the angle BAC comes out, $31^{\circ} 4\frac{2}{5}'$, representing the ascensional difference between the Sun and Venus; added to the Sun's right ascension, it establishes the right ascension of Venus, $65^{\circ} 20\frac{1}{3}'$.

On the same day, at 8h 45m in the afternoon, the distance between Venus and the southern star of Gemini [Meridionale Caput Π , the southern Head of the Twins] was found to be $40^{\circ} 14\frac{1}{2}'$. The declination of Venus, by the armillaries, was $22^{\circ} 49\frac{1}{2}'$, at the altitude of Venus 13° . The declination of the lower star of Gemini [inferioris Capitis Π] this year was $28^{\circ} 56\frac{2}{3}'$ north. The difference in right ascension of the two — of Venus and of the lower star of Gemini — was investigated in this way from the given declinations and distance.

In the figure we have used before, let B be Venus, C the lower star of Gemini. Therefore, in triangle BAC: the side BA, the complement of Venus's declination, is $67^{\circ} 10\frac{1}{2}'$; CA, the complement of the declination of the lower star of Gemini, is $61^{\circ} 3\frac{1}{3}'$; the side BC is $40^{\circ} 14\frac{1}{2}'$, the distance. From this, by the triangular process, the angle BAC is given, $44^{\circ} 28' 3''$, which measures the arc of the equator between Venus and the southern Head of Gemini. The interval of time between the one and this observation is 1h 45m, to which, for the daily motion of Venus — which is $1^{\circ} 17\frac{1}{2}'$ relative to the equator — there correspond $5' 37''$, which, added to the right ascension of Venus found above from the Sun, brings forth the right ascension of Venus for this...

corresponding to the time, $65^{\circ} 25' 57''$. Now if the arc of the equator between Venus and the upper Head of Gemini [Meridionale Caput Geminorum] is added to this, the right ascension of the upper Head of Gemini works out to $109^{\circ} 54' 0''$. The difference in right ascension between the upper Head of Gemini and the bright star of Aries [Lucida Arietis] is $83^{\circ} 57' 20''$; subtracting this leaves the right ascension of the bright star of Aries, for the year 1585 completed, as $25^{\circ} 56' 40''$. Since this is for a span of 2 years $3\frac{1}{2}$ months, we subtract the intervening proper motion, $1' 52''$, and the result for the year 1585 completed is $25^{\circ} 54' 48''$.

The right ascension of the same bright star of Aries, found above for the year 1587 from the 17th of August and reduced to the same completed year 1585, was

26° 5' 40", so that the difference between the two is 10' 52". This was produced by the entanglements of refraction and parallax left out of account. The difference here was on the larger side, because the Sun on both occasions stood quite low and so introduced a noticeable refraction. But since on both occasions exactly the same altitude was assumed, an equal refraction limited everything through the intermediate position. Now half of the difference between the two findings was 5' 26"; joined to the smaller right ascension, this gives the right ascension of the bright star of Aries as 26° 0' 0", corrected to the assumed time, which was what we were seeking.

X.

To investigate the same thing from other observations made on the same days, at a solar altitude of 5 degrees.

In the year 1587, on the 17th of August, at 5 h 30 m a.m., Venus was distant from the Sun 28° 13'. The declination of Venus, observed, was 19° 26' N. Its altitude was 28½°. The Sun's elevation was 5°. The Sun's place at that time, according to its proper restitution, was in 3° 2' 51" of Taurus [♉]. Its right ascension was 155° 0' 15". Its declination was 10° 25' 17" N.

Let A be the pole of the equator, B Venus, C the Sun. Since the triangle BAC has all its sides known — BA being 70° 34', the complement of the declination of Venus; CA being 79° 34¾', the complement of the declination of the Sun; and BC the distance between the two being 28° 13' — the angle BAC is therefore given as 27° 43½'. This is the difference in right ascension between the Sun and Venus; when it is subtracted from the right ascension of the Sun, it leaves the right ascension of Venus as 127° 16' 45".

On the same day, at 3 h 42 m a.m., the distance of Venus from the upper Head of Gemini [superiori Capite Geminorum] was 22° 20'. The declination of Venus was 19° 29¾' N. Its altitude was 14°. From this the difference in right ascension of the two became known as follows.

Diagram. A spherical triangle for the right-ascension reduction. The apex A is at the top; a long curved side runs down to B at the lower right, and a base arc CB runs across near the bottom, with a second lower arc D–E beneath it. The figure illustrates the triangle whose vertices are the pole of the equator (A), Venus (B), and the Sun (C).

- A (apex): pole of the equator
- B (lower right): Venus

- C (lower left, on the base arc): the Sun
- D (lower left, below C): auxiliary point on the lower arc
- E (lower right, below B): auxiliary point on the lower arc

In the same figure let B be taken as the Head of Gemini and C as Venus. The side BA is $57^{\circ} 17\frac{3}{4}'$, the complement of the declination of the upper Head of Gemini; CA is $70^{\circ} 30\frac{1}{4}'$, the complement of the declination of Venus; and BC, the distance between the two, is $22^{\circ} 20'$. From this the angle BAC will not stay hidden: it is $20^{\circ} 9\frac{1}{2}'$, exhibiting the difference in right ascension between Venus and the upper Head of Gemini.

The interval of time by which this observation of Venus preceded the other one from the Sun was 1 h 48 m. The daily motion of Venus in right ascension was $1^{\circ} 14'$. From this there falls to the stated interval of time $5^{\circ} 32''$, which is to be taken away from the right ascension of Venus as found from the Sun. The right ascension of Venus for this latter time is therefore $127^{\circ} 11' 13''$. Subtracting from this the ascensional difference between Venus and the upper Head of Gemini, we shall have the right ascension of the upper Head of Gemini as $107^{\circ} 2' 8''$. Its difference from the bright star of Aries, established from certain observations as $80^{\circ} 59' 45''$, becomes known again once it is removed: the right ascension of the bright star of Aries itself is $26^{\circ} 2' 23''$. For 1 year $7\frac{1}{2}$ months, subtract $1' 22''$, and the result for the year 1585 completed is a right ascension of the bright star of Aries of $26^{\circ} 1' 1''$, which, taken together with the next one from observations made toward sunset, comes up for comparison.

In the year 1588, on the 16th of April, p.m., at 6 h 48 m, the distance between Venus and the Sun was $30^{\circ} 50\frac{1}{2}'$. The Sun's altitude was 5° ; Venus was at 28° . The declination [of Venus] was $22^{\circ} 46' N$. The Sun's place from the Tables was $6^{\circ} 35' 49''$ of Taurus [♉]. The Sun's right ascension was $34^{\circ} 14' 55''$. The Sun's declination for the same time was $13^{\circ} 46' N$.

Therefore in this figure the side BA is $67^{\circ} 14'$, the complement of the declination of Venus to a quadrant of the circle; CA is $76^{\circ} 14'$, the complement of the declination of the Sun; and BC, the distance between the two, is $30^{\circ} 50\frac{1}{2}'$. Accordingly the angle BAC, $31^{\circ} 8' 44''$, measuring the difference in right ascension between the Sun and Venus, when added to the right ascension of the Sun, will yield the right ascension of Venus as $65^{\circ} 23' 39''$.

On the same day, p.m., at 8 h 40m [recte: $8\frac{2}{3}$ h], Venus was distant from the meridional Head of Gemini [Capite Geminorum] by $40^{\circ} 15'$. The declination of Venus was $22^{\circ} 49\frac{1}{2}' N$. Its altitude was $15\frac{3}{10}^{\circ}$. From this, by the same figure, in

which B will represent the Head of Gemini and C Venus, the difference in right ascension became clear. For BA is $61^{\circ} 3\frac{1}{3}'$, the complement of the declination of the lower [meridional] Head of Gemini; CA is $67^{\circ} 10\frac{1}{2}'$, the complement of the declination of Venus; and BC, the distance, is $40^{\circ} 15'$. So by the operation the angle BAC is $44^{\circ} 28' 40''$, discerning how great the ascensional difference of the lower Head of Gemini from Venus is.

The span of time between the observation of Venus from the Sun and the observation from this fixed star was 1 h 52 m, to which there correspond, by the daily equatorial motion of Venus, $1^{\circ} 17\frac{1}{2}'$, that is, $5' 59''$; by adding these to the right ascension of Venus noted above from the Sun, the right ascension of Venus...

Diagram. A spherical triangle similar to the preceding. The apex A is at the top; the long curved side runs down to the base near B and C at the lower right, with a lower arc from D to the right. It serves the reduction of right ascension via the Head of Gemini and Venus.

- A (apex): pole of the equator
- B (lower right): Venus / Head of Gemini (as assigned in the two operations)
- C (lower right, on inner arc): the Sun / Venus
- D (lower left): auxiliary point on the lower arc

of Venus suited to this time, $65^{\circ} 29' 38''$. Joined to the ascensional difference of Venus from the lower Head of Gemini, this produces the right ascension of the Head of Gemini as $109^{\circ} 58' 18''$. So that this may be brought down to the bright star of Aries, I subtract from it the difference in right ascension between the two, $83^{\circ} 57' 20''$ noted before, and the remainder will be the right ascension of the bright star of Aries, $26^{\circ} 0' 58''$. From this, for a span of two years and $3\frac{1}{2}$ months, deduct $1' 52''$, and the right ascension of the bright star of Aries comes out as $25^{\circ} 59' 6''$ for the year of Christ 1585 completed.

But above, from the year 1587, the 17th of August, the right ascension of the same star, referred to the year 1585 completed, was $26^{\circ} 1' 1''$; the difference between the two is $1' 55''$. Half of this, $58''$, joined to the smaller right ascension, shows the true right ascension of the bright star of Aries as $26^{\circ} 0' 4''$, which was what we sought.

XI.

From observations made in the year 1587 on the 18th of August, and in the year 1588 on the 28th of March, to attempt the same at a solar altitude of 10 degrees.

In the year 1587, on the 18th of August, at 4 h 6 m a.m., the distance between Venus and the bright foot of Gemini [Lucidum pedem Geminorum] was $33^{\circ} 17'$. The declination of Venus was $19^{\circ} 13' \text{ N}$. Its altitude was 15° . The declination of the foot of Gemini was $16^{\circ} 40\frac{1}{2}' \text{ N}$.

Therefore in the figure here laid out, let B be the bright foot of Gemini and C Venus. In the triangle BAC, since three sides are given — BA being $73^{\circ} 19\frac{1}{2}'$, the complement of the bright foot of Gemini; CA being $70^{\circ} 47'$, the complement of the declination of Venus; and BC being $33^{\circ} 17'$, the distance between Venus and the bright foot of Gemini — therefore by operating from a side, the angle BAC could not but be $34^{\circ} 56' 21''$, measuring the magnitude of the difference in right ascension between Venus and the bright foot of Gemini. And since Venus was not observed from the Sun on this day, we shall therefore apply here the value sought out from observations of Venus made on the 17th of August.

On the 17th of August, at 6 h 8 m a.m., Venus was distant from the center of the Sun $28^{\circ} 21'$, at a solar altitude of 10° , when Venus was being elevated to 33° , having a declination of $19^{\circ} 24\frac{3}{4}' \text{ N}$. The Sun's place from its proper Tables was $3^{\circ} 4' 23''$ of Taurus [♉]. Its right ascension was $155^{\circ} 1' 41''$. Its declination was $10^{\circ} 24\frac{1}{2}' \text{ N}$.

Diagram. A spherical triangle of the same kind. Apex A at the top; the long curved side descends to B at the right, the base arc C–B runs across, and a lower arc runs from D to E beneath. It serves the reduction involving the bright foot of Gemini and Venus.

- A (apex): pole of the equator
- B (lower right): Venus
- C (lower left, on the base arc): the Sun / bright foot of Gemini
- D (lower left): auxiliary point on the lower arc
- E (lower right): auxiliary point on the lower arc

Diagram. The first of two spherical triangles on this page (upper). Apex A at the top; the long curved side descends to B at the right, the base arc C–B runs across, and a lower arc runs from D to E beneath. It serves the reduction involving the pole, Venus, and the Sun.

- A (apex): pole of the equator
- B (lower right): Venus
- C (lower left, on the base arc): the Sun
- D (lower left): auxiliary point on the lower arc

- E (lower right): auxiliary point on the lower arc

Let B be Venus and C the Sun in this assigned figure. Let A be the pole of the equator. The sides of the triangle BAC are known. For BA is $70^{\circ} 35\frac{1}{4}'$, the complement of the declination of Venus; CA is $79^{\circ} 35\frac{1}{2}'$, the complement of the declination of the Sun; and BC, the distance between Sun and Venus, is $28^{\circ} 21'$. From this the angle BAC became known, $27^{\circ} 52' 32''$, which is the difference in right ascension between the Sun and Venus; it is to be subtracted from the right ascension of the Sun, and the remainder will be the right ascension of Venus, $127^{\circ} 9' 9''$.

The time interspersed between this observation and another made on the very next day was 21 h 58 m; since the daily motion of Venus from the 17th into the 18th, with respect to the equator, is $1^{\circ} 14'$, there correspond to it $1^{\circ} 7' 44''$, which, added to the right ascension of Venus found from the Sun, establish for the 18th, at 4 h 6 m, the right ascension of Venus as $128^{\circ} 16' 53''$. If from this we subtract the ascensional difference between Venus and the bright foot of Gemini sought out above, the right ascension of the bright foot of Gemini will be produced, $93^{\circ} 20' 32''$ [numeral: ?]. The difference in right ascension between the bright star of Aries [Clara Arietis] and the bright foot of Gemini, by certain observations, is $67^{\circ} 24' 35''$; removed from the right ascension of the bright foot of Gemini, it leaves the right ascension of the bright star of Aries as $25^{\circ} 55' 57''$. But for 1 year $7\frac{1}{2}$ months, subtract from this found value $1' 22''$, and there will remain the more corrected right ascension of the same star, $25^{\circ} 54' 35''$, for the year 1585 completed. Now let us proceed to the following year's observations, with which these are to be compared.

In the year 1588, on the 28th of March, p.m., at 5 h 28 m, the gap between the Sun and Venus was found to be $26^{\circ} 23'$. The Sun's altitude was 10° , Venus's 32° . Venus's declination was $16^{\circ} 30\frac{1}{2}'$ N. At this time the Sun's place was $18^{\circ} 3' 40''$ of Aries [γ]. Its right ascension was $16^{\circ} 38' 45''$. The Sun's declination was $7^{\circ} 6' 30''$ N. Accordingly, from these data, we shall easily obtain, as before, the arc of the ascensional difference between the Sun and Venus.

Let B be the Sun and C Venus in the figure prescribed. The side BA is $2^{\circ} 53\frac{1}{2}'$ [recte: ?], the complement of the declination of the Sun; CA is $73^{\circ} 29\frac{1}{2}'$, the complement of the declination of Venus; the side BC is $26^{\circ} 23'$, the distance between the two. And so the angle BAC was given as $25^{\circ} 13\frac{2}{3}'$, measuring the difference in right ascension between the Sun and Venus; added to the right ascension of the Sun, it comes out for this time to a right ascension of Venus of $41^{\circ} 52' 25''$.

Diagram. The second of two spherical triangles on this page (lower). Apex A at the top; the long curved side runs down to B at the lower right, the base arc C–B across, with a lower arc from D to E. It serves the reduction involving the Sun and Venus.

- A (apex): pole of the equator
- B (lower right): Venus
- C (lower left, on the base arc): the Sun
- D (lower left): auxiliary point on the lower arc
- E (lower right): auxiliary point on the lower arc

On that same day, in the afternoon at 7h 42m, the distance between Venus and Aldebaran was $20^{\circ} 23'$. The declination of Venus was $16^{\circ} 33' N$; the declination of Aldebaran was $15^{\circ} 36\frac{3}{4}' N$. The altitude of Venus at that time was $13\frac{1}{2}^{\circ}$. To investigate the ascensional difference, let in this figure B be Venus and C be Aldebaran.

Diagram. A spherical triangle drawn at the right of the page. Apex A is at the top (the pole of the equator); the curved sides run down to B at the lower right and through C and D at the lower left, with E at the lower right corner.

- A (apex): the pole of the equator
- B (lower right): Venus
- C (left, mid-height): Aldebaran
- D (lower left)
- E (lower right corner)

The triangle B A C has as its given side B A = $73^{\circ} 27'$ (the complement of the declination of Venus); C A = $74^{\circ} 23\frac{1}{4}'$ (the complement of the declination of Aldebaran); and B C = $20^{\circ} 23'$, measuring the distance between Venus and Aldebaran. From these, the angle B A C was found to be $21^{\circ} 12\frac{1}{4}'$, which is the ascensional difference sought.

The interval of time between the two observations was 2h 14m, to which, given the daily motion of Venus relative to the equator, there corresponds an intermediate motion of $6' 48''$. For the daily motion of Venus was $1^{\circ} 13'$. This intermediate motion is added to the right ascension of Venus as derived from the Sun, and the result is the right ascension of Venus appropriate to this time, namely $41^{\circ} 59' 13''$. To this right ascension of Venus add the ascensional difference between Venus and Aldebaran, and you will have the right ascension of the star itself, $63^{\circ} 11' 28''$. From this subtract the ascensional difference

between the bright star of Aries and Aldebaran, $37^{\circ} 3' 13''$, and there emerges the right ascension of the bright star of Aries, $26^{\circ} 8' 13''$.

From this in turn, for $2\frac{1}{4}$ years, subtract $1' 53''$, and the right ascension of the bright star of Aries for the year 1585 will be $26^{\circ} 6' 20''$. Compared with the right ascension of the same star found above from the day of August 18 in the preceding year, $25^{\circ} 54' 35''$, this gives a difference between the two of $11' 45''$, half of which is $5' 52\frac{1}{2}''$. If this be added to the smaller right ascension, it yields a corrected right ascension of the bright star of Aries of $26^{\circ} 0' 28''$ — which is precisely what we set out to investigate.

XII.

Finally, to accomplish this same result from the observations of the year 1587, on August 18, and of the year 1588, on April 16, at a solar altitude of 8° .

In the year 1587, on August 18, in the morning at 3h 55m, Venus was distant from the lower head of Gemini by $19^{\circ} 22\frac{1}{2}'$, and at the same instant the declination of Venus, observed by the armillae, was $19^{\circ} 13\frac{2}{3}'$ N. The altitude was 14° . By the help of these data, since the declination of the lower head of Gemini

was sufficiently known, the ascensional difference of each became known as follows. In this assigned figure, let A be the pole of the equator, B Venus, C the head of Gemini.

Diagram. A spherical triangle at the left of the page. Apex A at top; the curved sides descend to B and D at the lower left and to C (mid-right) and E at the lower right.

- A (apex): the pole of the equator
- B (lower left): Venus
- C (right, mid-height): the head of Gemini
- D (lower left corner)
- E (lower right corner)

The triangle B A C has as its given side B A = $70^{\circ} 46\frac{2}{3}'$ (the complement of the declination of Venus); C A = $61^{\circ} 34\frac{3}{4}'$ (the complement of the declination of the southern head of Gemini); and B C = $19^{\circ} 22\frac{1}{2}'$, the distance between the stars. From this, by the operation on the triangle, the angle of the ascensional difference between Venus and the meridional head of Gemini was derived: B A C = $18^{\circ} 24' 12''$.

But since Venus was not observed from the Sun on this day — the air after sunrise during the daytime being less clear — but rather only on the immediately preceding day, the right ascension of Venus, sought from that day, has to be accommodated here in the following manner.

On August 17, in the morning at 5h 50m, Venus was distant from the center of the Sun by $28^{\circ} 19\frac{3}{4}'$, measured by the trigonic sextant. Its declination was $19^{\circ} 25' \text{ N}$, by the armillae. The altitude of the Sun at that time was 8° ; the altitude of Venus 31° . The true place of the Sun was $3^{\circ} 3' 38'' \text{ Virgo}$ [Margin / sign: M]. The right ascension of the same was $155^{\circ} 0' 58''$; its declination $10^{\circ} 25' 8'' \text{ N}$. To find the ascensional difference between Venus and the Sun, let this diagram be taken, in which A is the pole of the equator, C the Sun, B representing Venus.

Diagram. A second spherical triangle lower on the left of the page. Apex A at top; curved sides descend to C (mid-left) and B (right) and to D and E at the bottom.

- A (apex): the pole of the equator
- B (right): Venus
- C (left, mid-height): the Sun
- D (lower left corner)
- E (lower right corner)

In the triangle B A C, the given side B A = $70^{\circ} 35'$ (the complement of the declination of Venus); C A = $79^{\circ} 34\frac{2}{3}'$ (the complement of the declination of the Sun); the side B C = $28^{\circ} 19\frac{3}{4}'$, the distance between the two. Therefore by calculation the angle B A C could not be unknown: $27^{\circ} 51\frac{1}{2}'$, which measures the arc of the equator intercepted between the Sun and Venus. Subtracted, therefore, from the right ascension of the Sun, it leaves the right ascension of Venus, $127^{\circ} 9' 38''$.

The interval of time by which this observation preceded the other from the meridional head of Gemini was 22 hours 5 minutes, to which, given the daily motion of Venus, $1^{\circ} 14'$, there corresponds, by reason of the equator, an intermediate motion of $1^{\circ} 8' 5''$. When this is added to the right ascension of Venus already found, the right ascension of Venus on August 18 at 3h 55m a.m., when the lower head of Gemini was observed from Venus, will come out as $128^{\circ} 17' 43''$. If now we take away from this right ascension of Venus the ascensional difference between Venus and the lower head of Gemini investigated above, there will remain the right ascension

of the meridional head of Gemini, $109^{\circ} 53' 31''$. And if from this we again subtract the ascensional difference reaching all the way to the bright star of Aries previously noted, $83^{\circ} 57' 20''$, the residue will be the right ascension of the bright star of Aries, $25^{\circ} 56' 11''$. To reduce this to the year of Christ 1585, for the span of one year subtract $1' 22''$, and it comes out, for that year, that the right ascension of the bright star of Aries to be sought first is $25^{\circ} 54' 49''$, and afterwards to be corrected by what follows.

In the year 1588, on April 16, in the afternoon at 6h 25m, the distance between the Sun and Venus was captured from the heavens as $30^{\circ} 52'$; the declination of Venus was $22^{\circ} 45\frac{2}{3}'$ N. The altitude of the Sun was 8° ; the altitude of Venus 32° . The place of the Sun was $6^{\circ} 34' 50''$ Taurus. The right ascension of the Sun's place was $34^{\circ} 13' 55''$; its declination $13^{\circ} 45\frac{2}{3}'$ N. Therefore, to find the equatorial distance between these two planets, let this prescribed figure be used, in which B is Venus, C the Sun.

Diagram. A spherical triangle at the right of the page. Apex A at top; the curved sides run down to B at left and C at right, then to D and E at the bottom corners.

- A (apex): the pole of the equator
- B (left): Venus
- C (right): the Sun
- D (lower left corner)
- E (lower right corner)

The side B A = $67^{\circ} 14\frac{1}{4}'$ (the complement of the declination of Venus); C A = $76^{\circ} 14\frac{1}{4}'$ (the complement of the declination of the Sun); the side B C = $30^{\circ} 52'$, the distance between the Sun and Venus. From these three given sides, the angle B A C was found by triangular calculation to be $31^{\circ} 9\frac{1}{2}'$, which marks off the ascensional difference between the Sun and Venus; and when added to the right ascension of the Sun, it gives the right ascension of Venus, $65^{\circ} 23' 25''$.

On the same day, in the afternoon at 8h 30m, Venus was distant from the bright foot of Gemini by $27^{\circ} 3\frac{1}{2}'$. The declination of Venus was $22^{\circ} 48\frac{1}{2}'$ N. The declination of the bright star in the foot of Gemini, known from sure observations, was $16^{\circ} 40\frac{1}{2}'$ N. The altitude of Venus at that time was $14\frac{1}{2}^{\circ}$. So, in the figure, let B be Venus, C the bright foot of Gemini.

Diagram. A second spherical triangle lower on the right of the page. Apex A at top; curved sides descend to B (mid-right) and C at the bottom, with D and E at the lower corners.

- A (apex): the pole of the equator
- B (right, mid-height): Venus
- C (left): the bright foot of Gemini
- D (lower left corner)
- E (lower right corner)

The side B A = $67^{\circ} 11\frac{3}{4}'$ (the complement of the declination of Venus); C A = $73^{\circ} 19\frac{1}{2}'$ (the complement of the declination of the bright star in the foot of Gemini); B C, the distance between this star of Gemini and Venus, = $27^{\circ} 3\frac{1}{2}'$. Therefore, since all these sides have been given, the angle B A C comes out as $38^{\circ} 2\frac{5}{8}'$ — the equatorial distance of Venus and the bright foot of Gemini.

The time elapsed between the two observations of Venus, namely from the Sun and from the fixed star, was 2h 5m, to which, the daily motion relative to the equator being $1^{\circ} 17\frac{1}{2}'$, there corresponds $6' 42''$, to be added to the right ascension of Venus found from the Sun, so that the right ascension of Venus appropriate to the later time

agrees, being $65^{\circ} 30' 7''$. There must now be added to this the ascensional difference of the bright star in the foot of Gemini from Venus, previously found, and the right ascension of the bright star in the foot of Gemini will be produced, $93^{\circ} 32' 57''$. Now the ascensional difference between this star and the bright star of Aries, according to our other observations, is $67^{\circ} 24' 35''$; and when this is subtracted from the right ascension of the said star, it leaves the right ascension of the bright star of Aries, $26^{\circ} 8' 22''$.

To reduce this to the completed year 1585, take away for 2 years and $3\frac{1}{2}$ months $1' 52''$, and for that completed year the right ascension of the bright star of Aries will be $26^{\circ} 6' 30''$. But because earlier, in the year 1587, from August 18, this same star was reduced to the same year 1585, the right ascension was found to be $25^{\circ} 54' 49''$; and the difference between the two being $11' 41''$, halved as $5' 50\frac{1}{2}'$, and either subtracted from the larger or added to the smaller right ascension, the right ascension of the bright star of Aries that was sought is found to be $26^{\circ} 0' 39''$. And since parallaxes and refractions, and any other impediments that might lie hidden, cancel each other out through a mutual comparison of this kind, there can be no doubt about it.

I have now reviewed those fifteen verifications of the brighter star at the head of Aries, made by means of the planet Venus through the Sun, with the utmost diligence, taken from the heavens in several preceding years. If, in enumerating them, I have been somewhat more long-winded, and have hammered home

everything by the repeated method of demonstration, this was done so that it might be established — not in passing, but with the subtlest precision applied — that all of this rests on accurate observations, on the infallible measurement of spherical triangles, and on a resolution into numbers properly ordered, and so that no one might be able to suspect that I had assumed so great an agreement and precision arbitrarily.

But that, in the last twelve of them, I have made no account of the refractions and parallaxes of the Sun and of Venus, as I did in the three earlier ones — this was done because, between the morning and the evening observation taken in turn, these would, especially through the assumption of an intermediate interval (as was done), excuse and cancel one another out. For the Sun everywhere, both in the morning and in the evening, at the times when the comparison was made, had exactly the same altitude; and therefore very similar parallaxes and refractions were caused, as nearly as possible. The star of Venus, too, being weighed in the balance on equal terms, so that its parallaxes and refractions might correspond to one another on both sides as far as could be, or might introduce the least possible discrepancy — and so that no tiny scruple might still lurk in these matters — for that reason I thought it more advisable to compare a larger number of observations with one another, so that one might correct and verify the other.

Now therefore, so that the particulars may be more rightly discerned at a single glance, with a recapitulation made, I shall set before the eyes the last fifteen right ascensions of the bright star of Aries, which had been limited and corrected, so that they may still be compared with one another more subtly and examined more scrupulously.

Collection of all the right ascensions of the bright star of Aries, determined from the fifteen Considerations recalled above, each adapted to the end of the year 1585.

The table below collects all fifteen determinations of the right ascension of the bright star above the head of Aries. Each of the fifteen observations (the date of each given by year, month, and day) yields a value of the right ascension reduced and adapted to the completed year 1585. The right-ascension values are given under the heading "A. 1585 comp. / Asc. r. Luc. ♈" (the right ascension of the bright Aries star computed for 1585), in degrees, minutes, and seconds. Every entry shares the same degree-and-minute portion, $26^{\circ} 0'$, so only the seconds vary from row to row.

In the second block of columns, rows I–III carry a note in place of a second observation date: "In his trib[us] nulla est adhibita viceversa collatio, sed solum occiduæ Obser[vationis] debitè verificatæ" — "In these three, no reciprocal comparison was applied; rather, only western observations, duly verified."

	Anni N ^o	Anni (Year)	Menses (Month)	Dies (Day)	Anni (Year)	Menses (Month)	Dies (Day)	A.1585 comp. Asc. r. ♀ (°)	()	()
I	1582	Februar	26	(see note)			26	0	4	4
II	1582	Martij	20	(see note)			26	0	3	2
II I	1582	Aprilis	3	(see note)			26	0	3	0
II II	1582	Februar	27	1585	Septem b.	21	26	0	2	0
V	1582	Martij	5	1585	Septem b.	14	26	0	3	8
V I	1582	Martij	5	1585	Septem b.	15	26	0	1	8
V II	1582	Martij	9	1585	Septem b.	15	26	0	3	2
V II I	1586	Decemb.	26	1588	Decemb.	15	26	0	4	2
I X	1586	Decemb.	27	1588	Nouemb .	29	26	0	3	7
X	1587	Ianuarij	9	1588	Decemb.	6	26	0	2	7
X I	1587	Ianuarij	24	1588	Octobris	26	26	0	2	9
X II	1587	Augusti	17	1588	Aprilis	16	26	0	1	4
X II I	1587	Augusti	17	1588	Aprilis	16	26	0	4	
X	1587	Augusti	18	1588	Martij	28	26	0	2	

Nº	Anni (Year)	Menses (Month)	Dies (Day)	Anni (Year)	Menses (Month)	Dies (Day)	A.1585 comp. Asc. r. ♀ (°)	(^{''} ([']))
II								8
II								
X	1578	Augusti	18	1588	Aprilis	16	26	0 3
V								9

After the table, the running text continues:

From all of these it is sufficiently clear that the discrepancy among them is exceedingly small — so slight that it scarcely exceeds half a minute. No room for doubt remains, and these investigations stand revealed as thoroughly accurate and careful. On their basis one may safely lay the foundation for the restoration of the fixed stars, free of any error perceptible to the senses. Indeed, one might rather marvel that such precision was ever attained at all than complain that there is some trifling disagreement of a few seconds — a matter of no consequence whatever. Yet so that even here some fitting and proper limit may be set, we shall do best if we establish the right ascension of the often-mentioned bright Aries star as roughly intermediate among all these values, in the manner that follows.

The bright star above the head of Aries, verified and finely delimited — the right ascension under number three — for the completed year 1585, which will set the foundation for all the rest.

G.	M.	S.
26.	0.	30.

With the bright star above the head of Aries set in place, as a kind of cornerstone, we shall now build up the arrangement of the remaining fixed stars — as many as one pleases. So that this may be done all the more fittingly and on a more solid footing, we shall first select certain especially prominent stars distributed around the whole circuit of the heavens along the Zodiac and the equator. From these — observed through their declinations and their distances — the differences in right ascension are to be deduced geometrically. When these differences are taken together, they should close an entire circle. In this way both the exact reliability of the instruments may be confirmed, and certain particular stars may be precisely positioned around the circuit of the whole heaven — a thing exceedingly well suited to the further investigation of the places of the remaining fixed stars and of the wandering stars [planets].

I wish, moreover, to test by a threefold collection and induction the very thing I have promised, and so to make it known.

First, by means of four prominent stars reaching from the bright Aries star around to that same star again, enclosing the whole compass of the heavens.

Second, to confirm the same result starting from this same star but by way of six particular stars, proceeding in the reverse direction from the other side.

Third, taking the beginning from the same point, to encompass the circumference of the heavens in the order of the signs [in consequentia] with the help of eight stars, and so to bring the earlier demonstration to its further conclusion. But so that this matter be delayed no longer, I shall now run through the whole business briefly.

On the right ascensions of certain principal fixed stars, built up demonstratively from their observed distances and declinations, so that they enclose the whole compass of the heavens around the Zodiac chiefly, or not far from the equator — and this by a threefold confirmation.

I. To comprehend the whole compass of the heavens by means of four stars, with respect to the equator.

Including the whole heaven first in a fourfold span, and taking the bright star of the head of Aries as our primary limit, in this first treatment we shall make use of the Meridional [southern] star of the Head of Gemini, of Spica of Virgo, and of the bright star of the Flying Vulture [Vega] — and this from observations previously gathered from the heavens and suitably completed for the often-mentioned year 1585.

The table gives, for each of the four stars (together with the bright Aries star repeated at the foot to close the circuit), its **Distance** [Distantia] from the next and its **Declination** [Declinatio], each in degrees [P.] and minutes [']:

No	Star	Distance — P.	Distance — '	Declination — P.	Declination — '	No
1	Bright star of Aries [Lucida ♈]			21	28 ½	1
		74	45 ½			

No	Star	Distance — P.	Distance — '	Declination — P.	Declination — '	No
2	Lower [southern] star of the Head of Gemini [Inferius Caput ♊]	90	46 ½	28	57	2
3	Spica of Virgo [Spica ♍]	97	50	8	56 ⅓	3
4	Bright star of the Vulture [Lucida Vulturis, Vega]	90	15	7	51 ⅓	4
	Bright star of Aries [Lucida ♈]			21	28 ½	

From these data — gathered from above with great diligence, and through instruments that are by no means deceptive — we shall investigate the ascensional differences of these stars repeatedly, partitioning the whole heaven, with the geometrical aid of the figure set alongside.

Let it be conceived that, in the diagram immediately following, B A C is the equinoctial colure [Colurus æquinoctiorum]; that B L C I represents the equator, whose pole is A; that D is the bright star above the head of Aries; E the Meridional [southern] star of the Head of Gemini; F Spica of Virgo; and G the bright star of the Vulture [Vega]. These four stars are joined to one another by little lines, taken to be the greatest arcs [great-circle arcs].

[Margin: + Vulturis ("of the Vulture") — a marginal correction/expansion keyed to "G Lucida +" in the body, identifying G as the bright star of the Vulture.]

Diagram. A large circle representing the celestial sphere in projection, with the equinoctial colure and the equator drawn as great circles across it and the four reference stars marked as small starbursts. The construction shows the right-angled spherical triangles by which the ascensional differences of the four stars are derived. Letters read off the figure:

- A (upper right, on the circle): the pole [Polus] of the equator, top vertex of the colure B A C.
- B (upper left, on the circle): one end of the equinoctial colure B A C.
- C (lower right, on the circle): the other end of the colure B A C; the equator B L C I terminates here as well.
- D (upper left, marked with a starburst, near B): the bright star above the head of Aries [Lucida Υ].
- E (center, marked with a starburst): the Meridional [southern] star of the Head of Gemini [Caput Meridionale Π].
- G (center-right, marked with a starburst, right of E): the bright star of the Vulture [Vega].
- F (lower right, marked with a starburst, near C): Spica of Virgo [Spica $\mathfrak{M}$].
- H (below B/D): foot of the perpendicular arc on the equator measuring the equatorial distance of the Aries star and the Gemini head (the arc H I).
- I (lower center, on the equator): point on the equator B L C I; the arc I K measures an ascensional difference.
- K (lower right, near F/C, on the equator): foot of a perpendicular arc dropped to the equator near Spica.
- L (center, on the equator below E/G): a labelled point on the equator B L C I.
- Dotted lines run from the pole A down through the stars to the equator, marking the feet H, I, K, L; solid arcs connect D–E–F–G as the great-circle sides of the triangles.

After the figure, the demonstration proceeds:

First, then, in triangle D A E: from the given sides D A and A E — the complements of the declinations of the bright Aries star [Lucida Υ] and of the Meridional star of the Head of Gemini [Π] — namely D A = $68^{\circ} 31\frac{1}{2}'$ and E A = $61^{\circ} 3'$, together with the third side D E (which represents the previously indicated distance of these stars from one another), the angle opposite this side, D A E, will not be hidden: $83^{\circ} 57' 33''$. The arc H I measures this angle, exhibiting the equatorial distance of the bright Aries star and of the Meridional star of the Head of Gemini.

By the same reasoning, in the other triangle E A F: since again three sides are known — E A = $61^{\circ} 3'$ as before; F A = $98^{\circ} 56\frac{1}{2}'$, derived from the declination of Spica of Virgo [Spica $\mathfrak{M}$] at the meridian, with K A added to make a full quadrant; and E F, known from the interval between its star [the Gemini head Π] and Spica — there emerges from these the angle E A F = $85^{\circ} 54' 13''$, showing the magnitude of the arc I K of the equator and likewise the ascensional difference of these stars.

Third, in triangle F A G the three sides are likewise given: F A, as before; G A, from the complement of the declination of the Bright Star of the Vulture [Lucida Vulturis = Vega], 82°8'40"; and F G, the distance between these stars, 97°50' (as also indicated earlier). The angle F A G will therefore not be lacking — the angle that gives the equatorial distance of Spica [Spica ♀] from the Bright Star of the Vulture, that is, the equatorial arc K L.

Lastly, in triangle G A D, returning once again to the Bright Star of Aries [Lucida ♀], all the sides are likewise known: G A, just indicated; D A, shown above; and D G, the distance between the Bright Star of the Vulture and the Bright Star of Aries, also reported earlier. The equatorial angle G A D will therefore be found: 93°22'58", the value measured by the equatorial arc L B H.

Having found these in this way, we will now compare and combine the equatorial distances of these four stars, to make it plain whether, taken together, they sum to the full circuit of the heavens as far as the equator is concerned — as will now become evident.

Ascensional difference from	to	p.	'	"
Bright Star of Aries [Lucida ♀]	Meridian of Capricorn [Merid. Cap. ♀]	83	57	33
Meridian of Capricorn [Merid. Cap. ♀]	Spica [Spicam ♀]	85	54	18
Spica [Spica ♀]	the Vulture [Vulturem]	96	45	9
the Vulture [Vulture]	Bright Star of Aries [Lucidam ♀]	93	22	58
Sum of all		35	59	58
		9		

Since, then, these four ascensional differences, gathered into one, so neatly fill out the entire circle of the equator — falling short by a mere two seconds, which carry no weight whatever — it is amply demonstrated from this that the positions of the stars we assumed are arranged precisely with respect to the equator, and that the observations from which their declinations and distances were derived were free of any fault. This is what we proposed to prove by this first line of reasoning.

II.

To establish the same point by six stars, through similar reasoning.

It is now worth intercepting the whole circuit of the equator by means of six stars, taken according to their ascensional differences. In the figure that comes next, where the more general matters are to be understood as before, let these be the stars:

1	D	Bright Star of Aries [Lucida Υ].	4	G — Spica Virginis [Spica of Virgo].
2	I	First Star of the Wing of Pegasus [Prima Alae Pegasi].	5	F — Heart of the Lion [Cor Leonis = Regulus].
3	H	Bright Star of the Vulture [Lucida Vulturis = Vega].	6	E — Northern Heel [Calx Borealis Π].

Since now, however, we proceed not in the order of the signs, as before, but rather in the reverse direction, returning back to the Star of Aries [Υ], it is worth confirming the matter this way. I will first set down, in the order of the stars assumed, their distances measured backward,

carefully taken from the sky, together with their declinations observed for the completed year of Christ 1585.

Diagram. A celestial sphere drawn in perspective as a circle, with an oblique great-circle band (the ecliptic/zodiac belt) crossing it from upper left to lower right and a second great circle (the equator) intersecting it. Point A is at the upper right on the sphere's outline; point G (with an adjacent outline point) lies at the lower right. A series of dotted great-circle arcs radiate from A down toward the lower-right region, and the six lettered stars (drawn as small starbursts) are distributed along the oblique band. The construction depicts the spherical triangles by which the ascensional differences of the six stars are derived.

Readable labels (position, content):

- A (upper right, on the sphere's outline): vertex A — common apex of the radiating arcs.
- D (upper left band, starburst): Bright Star of Aries [Lucida Υ].
- I (upper middle band, starburst): First Star of the Wing of Pegasus.
- B (left outline): point B on the sphere's edge.
- K (left, below B): point K.
- P (middle left): point P.
- E [?] (named in legend only — Calx pedis Π ; not resolvable on the plate).

- H (middle right, starburst): Bright Star of the Vulture [Vega].
- O (below H): point O.
- L (lower middle): point L.
- F (lower middle right, starburst): Heart of the Lion [Regulus].
- M (lower middle): point M.
- G (lower right, starburst): Spica Virginis.
- N (lower right, near outline): point N.
- G (lower-right foot of the band, on the outline): point G — intersection of the band with the sphere's outline.

Observations of the stars used here.

	Distantia (p.)	Distantia (')	Declinatio (p.)	Declinatio (')
Bright Star of Aries [Lucida Υ]	34	$37\frac{1}{4}$	21	$28\frac{1}{2}$ B.
First Star of the Wing of Pegasus [Prima Alae Pegasi]	47	$49\frac{2}{3}$	13	$0\frac{2}{3}$ B.
Bright Star of the Vulture [Lucida Vulturis = Vega]	97	50	7	$51\frac{1}{3}$ B.
Spica Virginis	97	50	8	$56\frac{3}{4}$ M.
Heart of the Lion [Cor Leonis = Regulus]	54	2	13	58 B.
Heel of the foot [Calx pedis Π]	54	$33\frac{3}{4}$	22	$38\frac{1}{2}$ B.
Bright Star of Aries [Lucida Υ]	58	22	21	$28\frac{1}{2}$ B.

Proceeding, then, in these derived data by means of six triangles — each of which has its sides given, and the equinoctial angle, which measures the ascensional differences — the result will not escape us.

I. — Triangle D A I

- Side D A, $68^{\circ}31\frac{1}{2}'$ — complement of the declination of the Bright Star of Aries [Lucida Υ].

- Side A I, $76^{\circ}59\frac{1}{3}'$ — complement of the declination of the First Star of the Wing.
- Side I D, $43^{\circ}37\frac{1}{4}'$ — distance of the Bright Star of Aries [Υ] from the First Star of the Wing of Pegasus.
- Therefore angle D A I, $44^{\circ}58'$ — ascensional difference of the Bright Star of Aries [Υ] from the First Star of the Wing of Pegasus.

II. — Triangle I A H

- Side I A, $76^{\circ}59\frac{1}{3}'$ — complement of the declination of the First Star of the Wing of Pegasus.
- Side A H, $82^{\circ}8\frac{2}{3}'$ — complement of the declination of the Bright Star of the Vulture [Vega].
- Side H I, $47^{\circ}49'$ — distance between the Vulture and the First Star of the Wing of Pegasus.
- Angle I A H, $48^{\circ}25'$ — ascensional difference between the two.

III. — Triangle H A G

- Side H A, $82^{\circ}8\frac{2}{3}'$ — complement of the declination of the Bright Star of the Vulture [Vega].
- Side A G, $93^{\circ}56\frac{1}{3}'$ — declination of Spica [Spica $\mathfrak{M}$] increased by 90.
- Side G H, $97^{\circ}50'$ — distance of Spica [Spica $\mathfrak{M}$] observed from the Vulture.
- Angle H A G, $96^{\circ}45\frac{1}{6}'$ — ascensional difference between the two.

IIII. — Triangle G A F

- Side G A, $98^{\circ}56\frac{1}{3}'$ — declination of Spica increased by 90. [recte: $93^{\circ}56\frac{1}{3}'$? — in triangle III above the same side A G is printed $93^{\circ}56\frac{1}{3}'$; here it reads $98^{\circ}56\frac{1}{3}'$.]
- Side A F, $76^{\circ}2'$ — complement of the declination of the Heart of the Lion [Cor ϱ , Regulus].
- Side F G, $54^{\circ}2'$ — distance of the Heart of the Lion [Cor ϱ] from Spica [Spica $\mathfrak{M}$].
- Angle G A F, $49^{\circ}19\frac{1}{2}'$ — ascensional difference of Spica from the Heart of the Lion [Cor ϱ].

V. — Triangle F A E

- Side F A, $76^{\circ}2'$ — complement of the declination of Regulus [Reguli].
- Side A E, $67^{\circ}21\frac{1}{2}'$ — complement of the declination of the Heel of the foot [Calcis pedis $\mathfrak{I}$].

- Side E F, $54^{\circ}33\frac{3}{4}'$ — distance between the Heel of the foot [II] and Regulus.
- Angle F A E, $57^{\circ}41\frac{1}{6}'$ — equatorial distance of Regulus from the Heel of the foot [II].

VI. — Triangle E A D

- Side E A, $67^{\circ}28\frac{1}{2}'$ — complement of the declination of the Heel of the foot [Calcis pedis II].
- Side A D, $68^{\circ}31\frac{1}{2}'$ — complement of the declination of the Bright Star of Aries [Lucida V].
- Side D E, $58^{\circ}22'$ — distance observed from the Heel of the foot [II] to the Bright Star of Aries [V].
- Angle E A D, $65^{\circ}28\frac{1}{2}'$ — ascensional difference of the Heel of the foot [II] from the Bright Star of Aries [V].

And now, by combining all these ascensional differences, we will test whether they make up a complete circle.

Collection of the prescribed angles into one sum.

A — from	to	p.	'	"
Bright Star of Aries [Lucida V]	First Star of the Wing of Pegasus [Primam Alae Pegasi]	44	58	0
First Star of the Wing of Pegasus [Prima Alae Pegasi]	Bright Star of the Vulture [Vulturis Lucidam = Vega]	48	25	0
Bright Star of the Vulture [Lucida Vulturis]	Spica [Spicam M]	96	45	9
Spica Virginis	Heart of the Lion [Cor ♌, Regulus]	49	19	20
Heart of the Lion [Corde Leonis]	Heel of the foot [Calcem pedis II]	57	4	10
Heel of the foot [Calce pedis II]	Bright Star of Aries [Lucidam V]	63	28	30
Sum of the differences		36	0	9
			0	

So, since the sum of all comes to precisely 360 parts (for the fact that 9 seconds are left over is utterly imperceptible), it is clearly confirmed from these results that the positions of the stars have been correctly distributed by us, and precisely designated with respect to the equator — and that the very instruments by which the required observations were taken were free of every fault.

Now, as a third trial, we will proceed to demonstrate the same point still further, by means of eight stars, so that the matter may become more evident.

III.

From the ascensional differences of eight stars — intercepting the equatorial periphery of the heavens by their ascensional differences — to conclude the same point still further.

Considering now the eight stars in the next figure that follows, which are to be understood by their assigned letters, together with the observation of their distances and declinations, as appears in the table below:

	Distant. (p.)	Distant. (°)	Declinat. (p.)	Declinat. (°)	
1 D Bright Star of Aries [Lucida ♀]	35	32½	21	28½ B.	1
2 E Eye of the Bull [Oculus ♂, Aldebaran]	45	5	15	36¼ B.	2
3 F Lower Head of the Twins [Inferius Caput ♀]	36	59½	28	57 B.	3
4 G Heart of the Lion [Cor ♀, Regulus]	54	2	13	58 B.	4
5 H Spica [Spica ♀]	42	33½	8	56½ M.	5
6 I North star of the left hand of Ophiuchus [Bor. sinist. man. Ophiuchi]	55	17½	2	33¼ M.	6
7 K Bright Star of the Vulture [Lucida Vulturis = Vega]	47	49⅔	7	51½ B.	7
8 L First Star of the Wing of Pegasus [Prima Alae Pegasi]	43	37¼	13	0⅔ B.	8
Bright Star of Aries [Lucida ♀]			21	28½ B.	

Diagram. A large sphere shown in perspective, representing the celestial sphere with the equator and the circuit of the eight principal fixed stars used in the ascensional-difference derivation. The pole of the equator is at the top (point A), from which a fan of dotted hour-circles (declination circles / meridians) radiates down toward the equatorial circle. Two great circles are drawn across the globe — the equator and an oblique circle — intersecting at the left margin (near B) and the lower right (near C). Eight star-symbols (rayed suns) are distributed along the oblique band of the figure, each lettered, with dotted lines running from the pole A to each star and on to the equator. The figure realizes the eight spherical triangles enumerated in the text below it.

Readable labels and their positions:

- A (top): pole of the equator; apex from which the declination circles radiate.
- B (upper left, on the rim): equatorial/circle intersection point.
- C (lower right, on the rim): the opposite intersection point.
- D (upper left, star symbol): first star of the circuit (the Bright Star of Aries).
- M (left, below B): point on the circle.
- E (left-center, star symbol): star (Aldebaran).
- T (center): intermediate point/letter on a dotted line.
- I (upper center, star symbol): star.
- F (center, star symbol): star (Southern/Meridional Head of Gemini).
- N (lower left): point on the circle.
- R (center-right, star symbol): star.
- O (lower left): point on the circle.
- S (center): point on a dotted line.
- G (lower center, star symbol): star (Heart of Leo / Regulus).
- P (lower left): point on the circle.
- I (lower center-right, star symbol): star.
- R (center-right, repeated label): point/letter.
- Q (lower right): point on a dotted line.
- H (lower right, star symbol): star.
- C (lower right rim): intersection point (as above).
- V (bottom): lowest point of the oblique circle on the globe.

From this arise eight triangles, each of which has all three of its sides known, and each will readily yield the angle that measures the ascensional difference at the equator, as will now be set out in order.

I. Triangle DAE.

- Side DA: 68 parts, $31\frac{1}{2}'$ — the complement of the declination of the Bright Star of Aries [Lucida Arietis].
- Side EA: 74 parts, $23\frac{3}{4}'$ — the complement of the declination of Aldebaran.
- Side DE: 35 parts, $32\frac{1}{8}'$ — the distance of the two from each other.
- Angle DAE: 37 parts, $3\frac{1}{4}'$ — the ascensional difference between the Bright Star of Aries and Aldebaran.

II. Triangle EAF.

- Side EA: 74 parts, $23\frac{3}{4}'$ — the complement of the declination of Aldebaran.
- Side FA: 61 parts, $3'$ — the complement of the declination of the Southern Head of Gemini [Meridional Head of Gemini].
- Side FE: 45 parts, $5'$ — the distance between them.
- Angle EAF: 46 parts, $53'$, $53''$ — the distance at the equator of Aldebaran from the Southern (Meridional) Head of Gemini.

III. Triangle FAG.

- Side FA: 61 parts, $3'$ — the complement of the declination of the Southern Head of Gemini, as before.
- Side GA: 76 parts, $2'$ — the complement of the declination of Regulus.
- Side GF: 36 parts, $59\frac{1}{2}'$ — the observed distance of the two.
- Angle FAG: 36 parts, $34'$, $47''$ — the ascensional difference between the Southern Head of Gemini and the Heart of Leo [Regulus].

IIII. Triangle GAH.

- Side GA: 76 parts, $2'$ — the complement of the declination of Regulus.
- Side AG: 98 parts, $56\frac{1}{3}'$ — the declination of southern Spica, taken to 90.
- Side HG: 54 parts, $2'$ — the distance between them.
- Angle HAG: 49 parts, $19\frac{1}{3}'$ — the ascensional difference between Spica and the Heart of Leo [Regulus].

V. Triangle HVI.

- Side HV: 81 parts, $3\frac{2}{3}'$ — the complement of the declination of Spica Virginis.

- Side VI: 87 parts, $26\frac{3}{4}'$ — the complement of the declination of the left hand of Ophiuchus.
- Side IH: 42 parts, $3\frac{1}{2}'$ — the observed distance of the two.
- Angle HVI: 42 parts, $19\frac{1}{3}'$ — the ascensional difference of the northern star in the left hand of Ophiuchus from Spica Virginis.

VI. Triangle IKA.

- Side IA: 92 parts, $33\frac{1}{4}'$ — the northern declination in the hand of Ophiuchus, taken to 90.
- Side AK: 82 parts, $8\frac{2}{3}'$ — the complement of the declination of the Vulture [Vega].
- Side IK: 55 parts, $17\frac{1}{2}'$ — the distance of the Vulture [Vega] from the northern star in the hand of Ophiuchus.
- Angle KAI: 54 parts, $26\frac{1}{3}'$ — the ascensional difference of the Vulture [Vega] from the northern star of the left hand of Ophiuchus.

VII. Triangle KAL.

- Side KA: 82 parts, $8\frac{2}{3}'$ — the complement of the declination of the Vulture [Vega].
- Side LA: 76 parts, $59\frac{1}{2}'$ — the complement of the declination of the First Star of the Wing of Pegasus.
- Side LK: 47 parts, $49\frac{2}{3}'$ — the distance of the First Star of the Wing of Pegasus from the Vulture [Vega].
- Angle KAL: 48 parts, $25'$ — the ascensional difference of the Vulture [Vega] from the First Star of the Wing of Pegasus.

VIII. Triangle LAD.

- Side LA: 76 parts, $59\frac{1}{2}'$ — the complement of the declination of the First Star of the Wing of Pegasus.
- Side AD: 68 parts, $31\frac{1}{2}'$ — the complement of the declination of the Bright Star of Aries [Lucida Arietis].
- Side DL: 43 parts, $37\frac{1}{4}'$ — the distance of the First Star of the Wing of Pegasus from the Bright Star of Aries.
- Angle LAD: 44 parts, $58'$ — the distance at the equator between the First Star of the Wing and the Bright Star of Aries.

Therefore, if we now combine these eight ascensional differences with one another as before, it will be clear — no less than before — that from the total sum

the whole circuit of the complete circle is quite precisely accounted for, as I will now lay before your eyes.

Collection of all the angles.

The ascensional difference from each of the stars at the left to each of the stars at the right, in degrees (P.), minutes (M.), and seconds (S.):

Ascensional difference from	to	M S		
		P.	.	.
Bright Star of Aries [Lucida Arietis]	Aldebaran	37	3	1 5
Aldebaran	Southern Head of Gemini [Mer. Caput II]	46	5	5 3 3
Southern Head of Gemini [Meridional Head of Gemini]	Heart of Leo [Cor Leonis]	36	3	4 4 7
Heart of Leo [Corde Leonis]	Spica Virginis	49	1	2 9 0
Spica Virginis	northern star of the left hand of Ophiuchus [Bor. sin. man.]	42	1	2 9 0
Northern star of the left hand of Ophiuchus [Bor. sinist. man. Oph.]	Bright Star of the Vulture [Vulturis Luc., Vega]	54	2	2 6 1
Bright Star of the Vulture [Lucida Vulturis, Vega]	First Star of the Wing of Pegasus [Prim. Alae Peg.]	48	2	0 5
First Star of the Wing of Pegasus [Prima Alae Pegasi]	Bright Star of Aries [Lucidam Arietis]	44	5	0 8
Aggregate		35	5	5 9 6

Therefore, since from the summed composition of these the entire circle is so aptly made up — falling short by only three seconds, and introducing not the slightest scruple — and since by this third line of reasoning, through the eight stars, their declinations and distances have been confirmed, and the ascensional differences collected from them are seen to be entirely correct, leaving nothing at all doubtful, whether in the instruments, in the conduct of the observation, or even in the working-out of the calculation: with this threefold corroboration so excellently established, we shall rest content. For although I have attempted the

very same thing with a great many other stars and by various methods, the result has always come back to the same point. And since it would be far too long to review here more abundant considerations on this matter, we shall be satisfied with these and now proceed to the further topics that build upon them.

On the longitudes and latitudes of the stars already adopted, to be investigated demonstratively from their right ascensions and declinations.

Since in what precedes the ascensional differences of several selected stars enclosing the whole circuit of the heavens have been established with sufficient exactness, and since the right ascension of the Bright Star above the Head of Aries [Lucida Arietis] has been carefully found and confirmed beforehand by fifteen separate investigations, it will not be difficult — by the successive addition of the equatorial differences, taking this Bright Star of Aries as the foundation — to collect the right ascensions of the rest. And once these are compared with the declinations of the same stars, it will be a straightforward matter to set out their longitude and latitude as well, with respect to the ecliptic.

For although the right ascensions and declinations of certain principal fixed stars enclosing the whole circuit of the heavens — especially around the zodiac and the equator — are of the greatest use in themselves, both for [the places] of the planets

and for marking out the more accurately and from the heavens themselves the places of the rest of the fixed stars — since some of them are everywhere ready to hand, and inasmuch as their right ascension and declination have been ascertained beforehand, by whose benefit the position of any unknown star can be taken by the instruments, and perhaps by a readier procedure than if these matters were reduced to the ecliptic; particularly if one chooses to undertake it from the distances and declinations, which become known more easily, or even by means of the equatorial armillaries, which we have in regular use, far more reliable and convenient than the ancient zodiacal ones —

nevertheless, since the motion of the fixed stars regards the poles of the ecliptic, not those of the equator, and since the places of the stars, both wandering [planets] and fixed, are reckoned in longitude and latitude along the ecliptic; and since, in relation to the fixed star itself, insofar as they are mutually unchangeable, they retain the same difference of longitude in perpetuity, and do not alter their latitude either — except insofar as it varies through the long course

of years by reason of the solar path, a discrepancy which, however, is not so great or so quickly perceptible (a matter we shall treat more fully later); whereas the declinations of the stars do change perceptibly from one year to another, and the ascensional differences themselves do not remain forever exactly the same: for this reason it will be especially fitting if we reduce the places of the adopted stars to longitude and latitude as well, along the ecliptic, with the method of demonstration appended.

But so that the data themselves may more readily be at hand, I will now set out in advance the right ascensions and declinations of these stars, as they were obtained from the observations of the year 1585, beginning from the Bright Star of Aries [Lucida Arietis].

The right ascensions and declinations of the stars previously employed, computed to the complete year 1585.

Names of the stars	Declination P.	Declination M.	Ascension R. P.	Ascension R. M.
Bright Star of Aries [Lucida Arietis]	21	28½ B.	26	0½
Eye of Taurus [Oculus Tauri, Aldebaran]	15	36¼ B.	63	3¾
Heel of the left foot of Gemini [Calx sinistri pedis]	22	38½ B.	89	29⅛
Lower Head of Gemini [Inferior Caput]	28	57¾ B.	109	58
Heart of Leo [Cor Leonis, Regulus]	13	57¾ B.	146	32¾
Spica Virginis	8	56⅓ M.	195	52⅛
Northern star of the left hand of Ophiuchus [Borealis sinist. manus Ophiuchi]	2	33¼ M.	238	11½
Bright Star of the Vulture [Lucida	7	51⅓ B.	292	37⅓

Names of the stars	Declination P.	Declination M.	Ascension R. P.	Ascension R. M.
Vulturis, Vega]				
First Star of the Wing of Pegasus [Prima Alae Pegasi]	13	0 $\frac{2}{3}$ B.	341	2 $\frac{1}{2}$

From these we will derive the longitudes and latitudes in the following manner.

A Clearer Treatment, for Chapter V [Lucidior ad Cap. V.]

In the accompanying figure, let BCDEF be the solstitial colure [Colurus Solstitiorum], GIE the ecliptic — whose pole is at C, F, K, I, D — and let it represent the equator with its own pole at B. Let A be the position of the bright star [the Lucida Arietis, Υ], through which two quadrants descend from each of the two poles to the said circles. It is evident, then, that KA measures the declination and IK the right ascension. The star's latitude with respect to the ecliptic is AH, and its longitude is IH', both of which we will obtain as follows.

In triangle BAC, two sides are given: side BC of $23^{\circ} 31\frac{1}{4}'$, the distance between the poles of the ecliptic and the equator, which we had previously determined carefully; and side BA of $68^{\circ} 31\frac{1}{4}'$, the complement of the declination of the bright star [the Lucida Arietis, Υ]. The angle ABC contained between them is the equatorial distance of the bright star Υ from the Tropic of Capricorn, which is measured by the arc of the equator KD. Therefore, if the quadrant of the circle ID is added to the given right ascension KI, the result is KD of $116^{\circ} 0\frac{1}{2}'$, which reveals the said angle. Hence, by the aid of triangles, the side CA will not remain hidden: $89^{\circ} 2' 57''$, indicating the complement of the star's latitude. And now, from the same triangle's three known sides, the angle BCA likewise becomes evident: $58^{\circ} 6' 50''$. To this corresponds the arc of the ecliptic GH, which shows the star's distance along the ecliptic from the summer tropic [Tropic of Cancer]; and when this is subtracted from the quadrant GI, it indicates the star's distance from the vernal equinox. Thus the longitude of the bright star above the Head of Aries Υ falls at that point at $1^{\circ} 53\frac{1}{8}'$ of Taurus φ , its latitude — from the complement found earlier — being $9^{\circ} 57'$ North.

And so, by means of a single triangle for the star in question, we have worked out both the longitude and the latitude from the given declination and right ascension — by a method perhaps more readily abridged than has hitherto been accomplished by our predecessors in a comparable task.

Now this same procedure must be carried out for the remaining stars. But since the course of the demonstration is one and almost everywhere the same — except that certain figures vary somewhat according to the differing position of the stars relative to the equator and the ecliptic — anyone who has grasped the matter from the demonstration already given will easily untangle the rest. In the following expositions, therefore, I will be briefer, indicating at least summarily the angles and sides, and the results that follow from them.

Diagram. A sphere showing the spherical-triangle construction for reducing the right ascension and declination of the Lucida Arietis to ecliptic longitude and latitude. The outer circle is the sphere; arcs are drawn through it representing the solstitial colure, the equator, and the ecliptic, intersecting at the star's position.

- B (upper left of circle): pole of the equator
- C (upper, right of B): on the solstitial colure
- A (interior, near center-top): position of the bright star (Lucida Arietis)
- G (left): on the ecliptic
- H (interior, left of center): foot of the latitude arc on the ecliptic
- F (left edge): on the colure / circle
- I (interior, center-low): intersection on the ecliptic
- K (lower-left interior): foot of declination/ascension arcs
- D (right edge): on the equator
- E (lower right): on the circle

Aldebaran, or the Eye of Taurus [Aldeboram sive Oculus ♉]

In the figure drawn here, A is the Eye of Taurus [Aldebaran], KA the declination, KI the right ascension; the rest as before. In triangle BAC, from the given side BC — which remains perpetually $23^{\circ} 31\frac{1}{2}'$ — and side BA, the complement of the declination, $74^{\circ} 23\frac{3}{4}'$, and the angle ABC of $153^{\circ} 3\frac{3}{4}'$ (reckoned from the right ascension counted from the beginning of Taurus ♉), the third side CA is gathered: $95^{\circ} 30' 51''$, whose remainder up to the quadrant gives the star's latitude.

Moreover the angle BCA is found: $26^{\circ} 0' 2''$, which measures the zodiacal distance of Palilicium (for this star is also so called by the Latins) from the Tropic of Cancer ♋, reckoning backward; and so, since its longitude — being two insensible seconds short — places it at $4^{\circ} 0'$ of Gemini ♊, removed from the vernal intersection, with its latitude, from the foregoing, coming out at $5^{\circ} 30\frac{3}{4}'$ South.

Diagram. A sphere with the spherical-triangle construction for Aldebaran (the Eye of Taurus), reducing right ascension and declination to ecliptic coordinates. Arcs of the colure, equator, and ecliptic cross within the circle at the star's position.

- B (upper, center-left): pole of the equator
- G (upper right): on the colure
- G (left): on the ecliptic [the letter G appears twice on this figure as printed]
- A (interior, left of center): position of the star (Eye of Taurus)
- H (interior, near A): foot of the latitude arc
- F (left edge): on the circle
- K (lower-left interior): foot of declination/ascension arcs
- I (interior, center): intersection on the ecliptic
- D (right edge): on the equator
- E (lower right): on the circle

Heel of the Northern Foot [of Gemini] [Calx Pedis Borei ♊]

Let the preceding figure be taken up here, and let A now be understood to be the star that occupies the heel of the left northern foot of Gemini ♊; the rest as before. In triangle BAC, besides BC which is always the same, BA is $67^{\circ} 21\frac{1}{2}'$ from the complement of this star's declination. The angle ABC now turns out to be $179^{\circ} 29\frac{1}{2}'$. Hence the third side CA is $90^{\circ} 52' 57''$; from which, with 90 subtracted, the remainder is to be assigned to the star's latitude. And since the angle BCA is found together with it as $28^{\circ} 40''$ [recte: $28^{\circ} 0' 40''?$], it shows the star to precede the summer tropic by just that little. Its longitude therefore falls at $29^{\circ} 31\frac{1}{3}'$ of Gemini ♊, its latitude — from the foregoing findings — being $0^{\circ} 53'$ South.

The Lower [Head of Gemini] [Inferius Caput ♊]

This star (which they also name Hercules or Pollux) is to be understood, in the accompanying diagram, as situated at A, the rest being conceived as before. It will now lie in triangle CBA: from the known distance of the poles CB, and BA the complement of the star's declination, $61^{\circ} 3'$, and the contained angle CBA of $160^{\circ} 2'$, the side CA is $83^{\circ} 2' 8''$, through whose complement the star's latitude is given. And the angle [BCA] further yields its distance from the Tropic of Cancer ☌ measured along the line of the ecliptic, which is gathered as $17^{\circ} 30' 26''$. Thus the longitude of the said star comes to just as many degrees and minutes of the sign Cancer ☌, together with the latitude made plain earlier: $6^{\circ} 58'$ North.

Diagram. A sphere with the spherical-triangle construction for the Lower Head of Gemini (Pollux), reducing right ascension and declination to ecliptic coordinates. Arcs of the colure, equator, and ecliptic intersect within the circle at the star's position.

- C (upper, left of B): on the colure
- B (upper center): pole of the equator
- A (interior, right of center): position of the star (Pollux)
- K (interior, near A): foot of an arc
- D (right, upper): on the circle
- E (right edge): on the equator
- G (left): on the ecliptic
- H (interior, center-low): foot of the latitude arc
- I (interior, lower center): intersection on the ecliptic
- F (lower left): on the circle

The Heart of the Lion [Cor Leonis]

That royal star (which they call the Heart of the Lion, or Regulus [Basiliscus]) is likewise to be measured from the preceding figure. It now comes out from the complement of the declination, $76^{\circ} 2\frac{1}{4}'$, and from the interval of the poles, known, together with the intercepted angle BCA [recte: ABC?] of $123^{\circ} 27\frac{1}{4}'$. The third side CA is $89^{\circ} 33\frac{1}{2}'$, whose remainder up to the quadrant is the star's latitude itself. The angle BCA is then made $54^{\circ} 4\frac{3}{4}'$, presenting the removal of Regulus (as the Greeks call it) from the Tropic of Cancer ☊. So that its longitude comes out at $24^{\circ} 4\frac{2}{3}'$ of Leo ♌, and its latitude, from what has been indicated, $0^{\circ} 26\frac{1}{2}'$ North.

Spica of Virgo [Spica Virginis]

The Ear of Grain, or Spica of Virgo [Arista sive Virginis Spica], is to be considered according to the accompanying design, where everything is now directed toward both [poles] — the southern pole, since this star is placed below the equator and the ecliptic — though the demonstration is nonetheless not unlike the preceding. And since in triangle BAC, side BA is the complement of Spica's ♍ declination, $81^{\circ} 3\frac{2}{3}'$, and side BC stands as above through the interval of the poles, the angle ABC here is found by subtracting the quadrant from the right ascension of Spica, $105^{\circ} 52\frac{1}{2}'$; side CA will be $88^{\circ} 1'$ or so, hence Spica's latitude is $1^{\circ} 59'$ South; and the

angle BCA comes out at $71^{\circ} 56\frac{2}{3}'$, showing the difference of Spica's ♀ longitude from the Tropic of Capricorn ♄. Its longitude therefore falls at $18^{\circ} 31\frac{1}{8}'$ of Libra ♎, its latitude — by the first reading — $1^{\circ} 59'$ South.

Diagram. A sphere with the spherical-triangle construction for Spica of Virgo, a star south of the equator and ecliptic, reducing right ascension and declination to ecliptic coordinates. Arcs of the colure, equator, and ecliptic intersect within the circle.

- F (upper right): on the colure
- E (left edge): on the equator
- I (interior, upper left): on an arc
- K (interior, center): intersection point
- G (right): on the ecliptic
- D (left edge, lower): on the circle
- H (interior, left of center): foot of an arc
- A (interior, near H): position of the star (Spica)
- C (lower right): on the circle
- B (bottom): pole of the equator

More Northerly Star in the Left Hand of Ophiuchus [Boreali or in sinist. manu Oph.]

Let A again be the position of the more northerly star of the third magnitude in the left hand of Ophiuchus, and let the rest stand as can be gathered from the preceding cases. From the known side BC, and BA the complement of the star's declination, $87^{\circ} 26\frac{3}{4}'$, with the angle ABC of $148^{\circ} 11\frac{1}{3}'$, the desired side CA is $107^{\circ} 20\frac{1}{3}'$, whose excess beyond the quadrant gives the star's latitude; and besides, the angle BCA is found to be...

Diagram. A sphere with the spherical-triangle construction for the more northerly star in the left hand of Ophiuchus, reducing right ascension and declination to ecliptic coordinates. Arcs of the colure, equator, and ecliptic cross within the circle at the star's position.

- F (upper right): on the colure
- E (left edge): on the equator
- H (interior, upper left): foot of an arc
- A (interior, left of center): position of the star

- K (interior, near A): foot of an arc
- I (interior, center): intersection on the ecliptic
- G (right): on the ecliptic
- D (left edge): on the circle
- B (bottom): pole of the equator
- G (lower right): on the circle [the letter G appears twice on this figure as printed]

33° 28' 53", which gives us its elongation from the Tropic of Capricorn [Tropico Hyberno]; whereby its longitude falls at 26° 31½' of Scorpio ♏, with the latitude, by the aforesaid excess, standing constant at 17° 20¼' North.

The Bright Star of the Flying Vulture [Lucida Vulturis volantis Stella]

Let A here too be taken for the position of the Lucida of the Eagle [Lucida Aquilae]. The rest as they have now become known: CA being taken as the complement of the Vulture's declination, 82° 8⅔'. And the angle BCA, 23° 37⅓', which is the distance of the right ascension derived from the Tropic of Capricorn [Tropico Hyberno], will reveal side BA of 60° 38½', the complement of the latitude of the star in question; and the angle ABC will come out at 154° 4' or so, showing how far the Lucida of the Vulture is removed from the summer solstice. Its longitude is therefore gathered as 25° 56' of Capricorn ♐, together with its latitude of 29° 21½' [North].

Diagram. A sphere with the spherical-triangle construction for the bright star of the Flying Vulture (the Lucida of Aquila/Vega region), reducing right ascension and declination to ecliptic coordinates. Arcs of the colure, equator, and ecliptic intersect within the circle.

- B (upper, left of C): pole of the equator
- C (upper center): on the colure
- A (interior, center): position of the star
- D (right, upper): on the circle
- E (right edge): on the equator
- F (left edge): on the circle
- K (lower-left interior): foot of an arc
- I (interior, center-low): intersection on the ecliptic

- G (lower left): on the circle
- H (bottom, center): on the colure

The First Star of the Wing of Pegasus [Prima Alae Pegasi]

By applying here too the same figure, so that A represents the first star of the Wing of Pegasus, it will be known — from BC given and AC the complement of the star's declination, $76^{\circ} 59\frac{1}{4}'$, and the intercepted angle of $71^{\circ} 2\frac{1}{2}'$ — that the third side BA is $70^{\circ} 34'$ or so, which is the complement of the star's latitude; and the angle ABC results as $77^{\circ} 4\frac{5}{8}'$, disclosing the difference of longitude from the Tropic of Capricorn [Tropico Hyberno], so that this star's longitude is consequently $17^{\circ} 44'$ — very nearly — of Pisces ♊, with a latitude of $19^{\circ} 26'$ North.

[Margin: + In the same latitude of Pollux, $6^{\circ} 38'$ B[orealis].] [?]

And these were the things we proposed to demonstrate and investigate concerning the longitudes and latitudes of these stars from the given declinations and right ascensions. Now, so that all their positions may be surveyed at a single glance, I will set them down.

Names of the Stars			S i g n			
[Nomina Stellarum]	Longitude — P. (deg.)	Longitude — M. (min.)		Latitude — P. (deg.)	Latitude — M. (min.)	N/S
Lucida ♈ [Lucida Arietis]	1	53	♈ 9		57	B. (No rth)
Aldebora[n]	4	0	♊ 5		31	M. (Sou th)
Calx ♊ [Heel of Gemini]	29	$31\frac{1}{3}$	♊ 0		53	M. (Sou th)
Pollux	17	$30\frac{1}{2}$	♊ 6		58	M. (Sou th)
Regulus	24	$4\frac{2}{3}$	♊ 0		$26\frac{1}{2}$	B.

Names of the Stars [Nomina Stellarum]	Longitude — P. (deg.)	Longitude — M. (min.)	S i g n	Latitude — P. (deg.)	Latitude — M. (min.)	N/S
						(No rth)
Arista [Spica]	18	3	♌	1	59	M. (Sou th)
Boreal. manus Ophiuchi [N. star, hand of Ophiuchus]	26	31	♍	17	20	B. (No rth)
Aquila	25	56	♏	29	21½	B. (No rth)
Prima Alae Pegasi [First star of Pegasus' wing]	17	44	♐	19	26	B. (No rth)

These positions of the stars set out above are in every way correct; they are sufficiently certain and reliable for use in investigating, from the heaven itself, the longitudes and latitudes of all the remaining stars, both fixed and wandering.

And although everything stated up to this point lays a solid enough foundation for building up a universal restitution of the stars — so much so that nothing further might seem to be needed — nevertheless I will still leave nothing untried, but will now test, by yet another line of reasoning applied to Spica Virginis, whether these limits of the fixed stars [Affixarum] have been correctly established, using its latitude and declination in the manner of Copernicus [more Copernicaeo].

The next task is to confirm, by a further method, that the limits of the fixed stars are precisely fixed with respect to the equinoctial points: namely, from the declination of Spica Virginis, with its verified latitude brought to bear.

Moreover, I will also examine — by the help of Aries [beneficio Arietis], the star that the ancients used most of all, and on which Copernicus alone, relying on the earlier age, founded his ordering of the precession of the equinoxes — the very thing I tried to test earlier: that is, whether the equinoctial terms (and therefore also the solstitial ones) of Lucida Arietis [Lucida Arietis] and of certain other principal fixed stars around the zodiac are duly disposed. For this purpose that star is more convenient than the others, since it is not so very far removed from the autumnal equinox, and so its declination varies appreciably over only a few years — and it is from this declination that I intend to investigate its longitude.

But since declination alone is not enough for investigating the distance from the equinox, unless an exact latitude has also first been supplied together with it, it will above all be worthwhile to investigate the latitude of this star carefully, and once it is exactly determined, to make it reliable — taking care not to adopt the value handed down by the ancients, lest we stumble into the very thing that we did not approve of above in the case of Copernicus and Werner [Werner].

Therefore, so that we may be able to establish something certain about the latitude of this star, by a method of its own, I will set up this procedure starting from a certain small star of Draco, near to the ecliptic pole, which is roughly of the third magnitude and which in its longitude tends very nearly toward the autumnal equinox, and which is thus, of all the stars near that pole, directed toward Spica more than any other. And the procedure will be such that I shall first verify the longitude and latitude of this star by means of certain other stars in the zodiac — particularly ones near the summer tropic — and then, from this star together with a certain other assumed one, I shall trace out the latitude of Spica Virginis along the zodiac, as will now become clear in due order in what follows.

On the investigation of the longitude and latitude of a certain small star of Draco near the ecliptic pole — one of the third magnitude — so that from it the latitude of Spica Virginis may be sought

[Body heading, p. 210, in italic display type: *De Inquisitione Longitudinis atq Latitudinis Stellulae cuiusdam Draconis Polo Ecliptica vicinae, quae tertiae est magnitudinis, ut hinc Spicae ♍ Latitudo inquiratur.*]

For this purpose, then, I will take the positions of four stars whose longitude and latitude are already given — namely, Lucida Arietis [Lucida ♈], the Foot of Gemini [Calcis ♊], the Lower Head of Gemini [Inferioris Capitis ♊], and Regulus [Reguli] — exactly as they were carefully arranged according to zodiacal

longitude and latitude by us in the preceding pages, from which they can be recalled here. From these I will first investigate the exact position of that small star of Draco which approaches the ecliptic pole. Then, through this star, with one or another of the stars already mentioned now assumed, the latitude of Spica Virginis will be traced out (as I said) — and that by a threefold repetition of the procedure, so that the matter under investigation may come out the more correctly.

I.

To ascertain, by means of Lucida Arietis and the Foot of Gemini, the longitude and latitude of the star of Draco that is near the pole

[Body heading, p. 211, in italic: *Per Lucidam ♈ & Calcem pedis ♊, Stellae Draconis, quae Polo propinqua est, Longitudinem atq Latitudinem persentiscere.*]

In the assigned figure, let P be understood as the ecliptic pole, A as Lucida Arietis [Lucida ♈], B as the Foot of Gemini [Calx pedis ♊], and C as the assumed small star of Draco — for by means of these I prefer to test the whole matter first, and then to confirm it from the rest. Let arcs therefore be drawn from the ecliptic pole to the ecliptic itself, a portion of which is represented by DEF, and let the positions of the stars be joined to one another by arcs of great circles. It is then evident that PC measures the latitude of the star of Draco, and that the angle BPC measures the difference of its longitude from the Foot of Gemini — which are the two things we are anxious to find out. The longitude and latitude of Lucida Arietis and of the Foot of Gemini are already established from before; but the distances between the stars, by means of an exquisite instrument exhibiting the intervals — and, where need be, even by quadrants of the larger circles — displaying them very scrupulously, have been found from the heavens itself in this manner, several times over.

Between Lucida Arietis and the star of Draco, AC: 84 parts 20½ minutes. From the Foot of Gemini to the same star of Draco, BC: 90 parts 37 minutes. Lucida Arietis and the Foot of Gemini, AB, are 58 parts 21½ minutes apart.

Diagram. A curvilinear (spherical) triangle whose apex is the ecliptic pole P at the top. From P, arcs descend to a curved base arc DEF (a portion of the ecliptic) running along the bottom, with D at the lower left and F at the lower right. The interior carries the stellar positions: A (on the left flank) is Lucida Arietis, B (near the bottom center, between D and E) is the Foot of Gemini, and the labels E and the apex region form the construction. G appears on the right flank between P and F, marking the small star of Draco / great-circle intersection.

- P (apex, top): Pole of the ecliptic [Polus Eclipticae]
- A (left flank): Lucida Arietis [Lucida Υ]
- B (lower center, between D and E): Foot of Gemini [Calx pedis Π]
- C / G (right flank, upper): the assumed small star of Draco [Stellula assumpta Draconis] — labelled G on the right arc; C in the text
- D (lower left): point on the ecliptic arc
- E (lower center, right of B): point on the ecliptic arc
- F (lower right): point on the ecliptic arc
- DEF (base): portion of the ecliptic [portionem repraesentat DEF]

Therefore, since in triangle APB two sides are given together with the included angle — for PA is the complement of the latitude of Lucida Arietis, 80 parts 2 minutes 57 seconds; the side BP is made up of the latitude of the Foot of Gemini added to a quadrant, 90 parts 52 minutes 57 seconds; while the angle APB is known from the difference of longitude of these stars, 57 parts 58 minutes 10 seconds — from the principles of triangles the third side BA becomes known: 58 parts 21 minutes 48 seconds. This even determines the interval between Lucida Arietis and the Foot of Gemini, exceeding the value observed by the instrument by at most about a quarter of one minute, which is here of no consequence. From all the now-known sides AB, P of the said triangle, by computation as well

the angle PBA is found: 77 parts 43 minutes 57 seconds. Next, in triangle BAC, since the three sides are also established — BC, the distance of the Foot of Gemini and the star of Draco, 90 parts 37 minutes; AC, of Lucida Arietis and the same star of Draco, 84 parts 20½ minutes; and BA, the interval between Lucida Arietis and the Foot of Gemini, just now made known by computation, 58 parts 21 minutes 48 seconds — therefore the angle CBA too can be obtained from the sides: 82 parts 57 minutes 51 seconds. Then, proceeding to triangle BPC, where two sides are known — PB, made up of the latitude of the Foot of Gemini added to a quadrant, 90 parts 52 minutes 57 seconds, and BC, the interval between the star of Draco and the Foot of Gemini, 90 parts 37 minutes — the angle PBC is obtained thus: by subtracting the angle PBA from the angle CBA (as a part from its whole, both having been found before), the angle PBC remains known: 5 parts 13 minutes 54 seconds. And so the third side PC will also be found: 5 parts 14 minutes 17 seconds. And from the three sides now known, the angle BPC will likewise be established: 87 parts 7 minutes 30 seconds. Now the side PC represents the complement of the latitude of the star of Draco, while the angle BPC determines the difference of its longitude from the Foot of Gemini. From this the longitude

and latitude of this star of Draco is now sufficiently clear, just as we set out to investigate. And it is as follows:

	p.	'	"
Longitude	26.	38.	50.
Latitude	84.	45.	43.

II.

To explore the same thing, from the distance of the same small star to the more southerly Head of Gemini, and the Foot already assumed

[Body heading, p. 212, in italic: *Idem, ex distantia eiusdem Stellulae à Meridionaliori Capite II, atq iam assumta in Calce explorare.*]

In the figure set alongside, let B be the lower Head of Gemini [inferius Caput II], A the Foot of Gemini [Calx ped. II], and C the small star of Draco. The rest is to be understood as before. The distance between the star of Draco and Pollux [Pollucem], CB, I have ascertained to be 81 parts 31 minutes 3½ seconds. The distance CA between the Foot and the star of Draco was indicated before to be 90 parts 37 minutes. Therefore, in triangle ABP, since two sides are given — PA, 90 parts 52 minutes 57 seconds as before, and PB, 83 parts 22 minutes 8 seconds, the complement of the latitude of the lower Head of Gemini — and the angle of the difference of longitude APB, 17 parts 59 minutes 10 seconds, the side BA will not be unknown: 19 parts 27 minutes 40 seconds. This interval of the two assumed stars of Gemini agrees well enough with the heavenly observation, and from the three angles of the same now known...

Diagram. A spherical triangle with apex P (ecliptic pole) at the top and a curved base running along the bottom from D (lower left) through A and E to F (lower right). Several great-circle arcs descend from P. The interior point B sits above the base between the descending arcs, with the small stellar configuration A–B–E clustered at the lower left.

- P (apex, top): Pole of the ecliptic [Polus Eclipticae]
- A (lower left, on/near base): Foot of Gemini [Calx pedis II]
- B (interior, above base, center-left): lower Head of Gemini [inferius Caput II]
- C (upper right flank): the small star of Draco [Stellula Draconis]
- D (lower left corner): point on the ecliptic arc
- E (lower center, right of A): point on the ecliptic arc
- F (lower right corner): point on the ecliptic arc

angle PAB will not escape us either: $67^{\circ} 1' 50''$. Next, in triangle BAC, since here too three sides are given, the angle BAC—as is clear enough to anyone paying attention—will likewise be established as $61^{\circ} 48' 1''$. Finally, in triangle PAC, since the two sides PA and CA are known together with the angle they enclose, that angle being found by subtracting angle BAC from angle PAB (computed both ways), the result is $5^{\circ} 13' 50''$. This can be no other than arc PC, which represents the complement of the latitude of the star of Draco: $5^{\circ} 14' 11''$. And so the true latitude of the star comes out as $84^{\circ} 45' 49''$, differing from the value found above by at most six seconds—as is plain.

Now I should like to investigate this same latitude of the star of Draco by yet another method from the same preceding figure, through the angle at B—since the matter we are pursuing requires so much precision. For in triangle PBA, all three sides are known, and so angle ABP comes out as $112^{\circ} 3' 27''$. Likewise in triangle ABC, with all the sides known, angle CBA will be established as $117^{\circ} 0' 16''$. Subtracting from this the former angle APB [recte: ABP] leaves angle CBP known: $4^{\circ} 56' 49''$. Then in triangle BPC, from the angle known at B and the sides BP and BC enclosing that same angle—as is clear from what precedes—there results once again the side PC: $5^{\circ} 14' 14''$. This marks the complement of the latitude of the star of Draco, and so gives the latitude itself as $84^{\circ} 45' 46''$ —which comes still closer to the latitude found above, exceeding it by at most three seconds. Moreover, in the said triangle BPC the angle at P is found to be $69^{\circ} 7' 56''$, which supplies the difference in longitude between the star of Draco and the lower [star] in the chapters on Gemini [II]. Therefore, when this is added to the longitude of the said [lower] star of Gemini indicated above, it yields the longitude of the star of Draco as $26^{\circ} 38' 26''$ of Virgo, which differs imperceptibly from the value found earlier.

III.

To examine this same point still more clearly from the lower head of Gemini [II] and the Heart of Leo [Ω].

The often-mentioned star of Draco was found, with great diligence applied, to be distant from the Heart of Leo by $85^{\circ} 9'$; and from the lower head of Gemini [II] by $81^{\circ} 31\frac{1}{2}'$, as I also indicated before. So in the next following diagram let E be the Heart of Leo, A the lower head of Gemini [II], C the little star of Draco, and the rest as before.

First, in triangle ABP the two sides PA and PB are known—from the complements of the two latitudes taken from the Zodiac of the fixed stars—and the angle APB is

established well enough from the difference of their longitudes. And so the third side BA will not be unknown either: $36^{\circ} 59' 53''$, giving the very distance between the stars,

which the heavens themselves taught me to be 37° on several occasions. And from the three known sides of the same triangle, angle PBA comes out as $79^{\circ} 31' 50''$. Furthermore, triangle BAC has its three sides known, from the distances of the three assumed stars from one another; therefore angle CBA will not be concealed from us either: $82^{\circ} 21' 20''$. Finally, in triangle PBC, from the sides PB and BC being known together with the enclosed angle PBC—which is obtained by subtracting angle PBA from angle CBA, $2^{\circ} 49' 32''$ —the third side PC will be needed no longer: $5^{\circ} 14' 0''$; and in addition BPC comes out openly as $32^{\circ} 34' 30''$. Now the side PC is the complement of the latitude of the star of Draco, which indicates its latitude as $84^{\circ} 46' 0''$; and BPC presents the difference in longitude from the Heart of Leo. From this, added to the longitude of the place of Regulus, it produces the longitude of the star of Draco as $26^{\circ} 39\frac{1}{3}'$ of Virgo—which I resolved to investigate by this third trial.

Diagram. A spherical triangle (lune-shaped construction) for the third determination of the little star of Draco near the pole of the zodiac, drawn from the apex P (pole of the ecliptic) down to a base line. The figure shows great-circle arcs converging at the top vertex and a base line through several lettered points.

- P (top apex): pole of the ecliptic
- C (just below P, on the right arc): the little star of Draco
- A (lower left): the lower head of Gemini [II]
- B (lower right, on the base): assumed star
- G (base, far left): foot of the perpendicular / ecliptic point
- F (base, center-right): point on the base line
- E (base, far right): the Heart of Leo

Now I will set before the reader all three positions of this little star of Draco, obtained in different ways through the three derivations, so that the very small difference that occurs may be more precisely delimited.

The place of the little star of Draco near the pole of the zodiac, investigated three ways.

		Longitude (p. ' ")	Latitude (p. ' ")
I	Lucida Arietis [Υ] & Foot of Gemini [II]	$26^{\circ} 38' 50''$ ♍	$84^{\circ} 45' 43''$ B.

	Longitude (p. ' ")	Latitude (p. ' ")
I e Foot of Gemini [II] & I x lower head of Gemini [II]	26 38 26 ♀	84 45 46 B.
I Lower head of Gemini I [II] & Heart of Leo [Ω] I	26 39 10 ♀	84 46 0 B.

When these are compared with one another and weighed in the balance, it will be more certain if we determine the longitude of the little star of Draco together with its latitude as follows.

The more certain and delimited place of the little star of Draco.

	p.	'	"
Longitude	26	38	50 ♀
Latitude	84	45	53 Boreal

And so, with this position of it verified, taken as a fixed and scrupulously examined fact, it will be quite safe to use it in determining the latitude of Spica [♊].

I want to add this further point in passing: in this procedure I made use chiefly of the zodiacal stars near the summer tropic, and above all the one in the Foot of the upper Gemini [II] and the lower one in the Head of the other [twin], so that in any given derivation one of these would have the principal role in the work. For since these stars change their declination most slowly—especially the one in the Foot, being so close to the point of the summer solstice—the latitude can be had with certainty from its declination alone, once the maximum obliquity of the ecliptic is subtracted, even if its longitude has not been established with full precision. Much the same holds for the star Pollux, though not so evidently, since it is farther removed from the solstice. For this reason I entrusted this task chiefly to these stars, while adjoining two others—namely Lucida Arietis [♈] and the Heart of Leo—so that the triangle could be more conveniently fitted together.

Now, therefore, I will proceed to establish the latitude of Spica Virginis [♍], for whose sake I undertook this labor, and that by a twofold trial: once with this star of Draco brought in alongside Regulus; and second, with the lower head of Gemini [II], as will be shown shortly.

I.

For the latitude of Spica [♏], from its given interval to the assumed little star of Draco and the Heart of Leo.

By means of a certain instrument that precisely affords distances between stars even greater than a sixth part of a circle, or a quadrant if need be, I repeatedly measured the little star of Draco, which is near the pole of the zodiac, as removed from Spica [♏] by $87^{\circ} 6\frac{1}{2}'$. I did this above all when Spica [♏] was near the meridian, the air being thoroughly clear, so that it would not be subject to noticeable refraction. In the same way I found that between the Heart of Leo [♌] and this star of Draco there intervened $85^{\circ} 9'$ (as was also indicated before). The interval between Spica and the Heart of Leo I scrutinized faithfully several times with the astronomical sextant, finding it $54^{\circ} 2'$ —or, if we sift everything too scrupulously, less by a sixth part of one minute, which nonetheless almost wholly escapes the sense of the eyes and makes no difference here, whether it be allowed or not. From these data we shall now lay open the latitude of Spica [♏] by the following reasoning.

In the next following diagram, let P be conceived as the pole of the ecliptic, and let arc DBF represent some portion of it. Let A be the Heart of Leo, through whose place the arc PAD descends from the pole into the ecliptic. Let B represent the star of Draco, to which likewise an arc BBE [recte: ζ BE] passes from the pole into the ecliptic. And let C be Spica [♏] itself, whose latitude I am investigating—which is joined both to the pole of the ecliptic

and to the two assumed stars by arcs of great circles. With this groundwork laid, consider first triangle PBA, where two sides are given together with the enclosed angle: PA is $89^{\circ} 33' 30''$, the complement of the latitude of the star of the Heart of Leo [♌]; PB is $5^{\circ} 14' 7''$, the complement of the latitude of the star of Draco; and angle APB is $32^{\circ} 34' 10''$, known from the difference in longitude of the Heart of Leo [♌] and the star of Draco. From this, by the reasoning of triangles, the third side BA will also be made manifest: $85^{\circ} 8' 59''$, showing the distance of the Heart of Leo [♌] from that star of Draco, in agreement with the observation noted above so precisely that at most a single second second—wholly imperceptible—would be wanting.

Diagram. A spherical-triangle construction for the latitude of Spica, drawn from the apex P (pole of the ecliptic) with great-circle arcs descending to a base line representing the ecliptic.

- P (top apex): pole of the ecliptic
- B (upper middle, on the central arc): the star of Draco
- A (lower left): the Heart of Leo [Ω]
- D (base, far left): ecliptic point below A
- E (base, center): point on the ecliptic
- F (base, right): ecliptic point
- C (lower right): Spica [$\mathbb{M}$]

Moreover, from the three now-known sides of the same triangle, angle PAB becomes known: $2^{\circ} 49' 38''$. Further, in triangle BAC, since all the sides are constant—from the very distances of the stars, gathered from the heavens by observations least open to doubt, which I set out at the start—angle BAC will not escape us: $79^{\circ} 56' 40''$. Finally, in triangle PAC, the side PA is known: $89^{\circ} 33' 30''$, namely the complement of the latitude of the Heart of Leo; and CA, from the distance between Spica and the Heart [of Leo], is $54^{\circ} 2'$, as was likewise reported earlier. The angle enclosed by these sides, PAC, is gathered by combining the two angles PAB and BAC together: $92^{\circ} 46' 18''$. Therefore the triangular operation will readily yield the third side PC: $91^{\circ} 59' 0''$, which determines the removal of Spica Virginis from the boreal pole of the ecliptic. And so, once a quadrant of the circle is taken away from this, there will remain Spica's latitude itself: $1^{\circ} 59'$ south, precisely—which we had proposed to render known by this method.

II.

The investigation of the same [latitude of Spica $\mathbb{M}$] by means of the distance of Spica [$\mathbb{M}$] from the lower head of Gemini [II] and from the little star of Draco itself.

But it will also be advisable to confirm this same thing by means of Hercules, or Pollux, with a comparison made to the star of Draco and applied to Spica, so that by a twofold testimony the matter we are aiming at may be ratified.

In the diagram set out here, then, let P likewise be the Arctic pole of the ecliptic; A, the lower star of the head of Gemini [Caput II — "Caput Geminorum," the lower head-star]; B, the star of Draco; and C, Spica Virginis. Let arcs be drawn and all the parts duly connected, as before.

Now the interval between Spica and the star of Draco is again taken as before, $87^{\circ} 6\frac{1}{2}'$, represented by arc BC. The distance of Spica Virginis from the lower star of the head of Gemini [inferioris Cap. II] — measured with the instrument mentioned above, with which I have often determined stellar distances greater than a quadrant very accurately — is given by arc AC as $90^{\circ} 46\frac{1}{4}'$. And the interval

between the star of Draco and the said head of Gemini [dictum Caput II], $81^{\circ}31\frac{5}{8}'$, corresponds to arc BA.

Reasoning, then, as before: first, in triangle APB, where two sides are given together with the contained angle — PA, being the complement of the latitude of the lower star of the head of Gemini, will be $83^{\circ}22'8''$; PB, the complement of the latitude of the star of Draco, $5^{\circ}14'7''$; and the angle APB, equal to the difference in longitude of the two stars, $69^{\circ}8'20''$ — the remaining side BA is subject to determination: $81^{\circ}31'52''$. This also gives the interval between these two stars, in close agreement with the observation itself, so that only two seconds escape it — a discrepancy beneath all perception. In the same triangle, too, the angle PAB, now that the three sides are known, cannot remain hidden: it comes out as $4^{\circ}56'42''$.

Now, proceeding to triangle BAC, which likewise has three known sides — denoted by the mutual distance of all three stars — the angle BAC will accordingly come out as $86^{\circ}57'41''$. Finally, considering triangle PAC, whose side PA is $83^{\circ}22'8''$ as before, and CA $90^{\circ}46\frac{1}{4}'$ as previously established, and the angle they enclose, PAC, composed from the two angles PAB and BAC just found, comes to $91^{\circ}54'23''$. Therefore the third side will by no means be unknown: $91^{\circ}58'57''$. This brings into the open the digression of Spica Virginis from the Arctic pole of the ecliptic; and from this, the quadrant of a great circle being subtracted, the latitude of that same star — which we were seeking — turns out to be $1^{\circ}58'57''$ south. This squares quite precisely with the value found a little earlier, the difference amounting to only three seconds, which is of no account whatever.

Therefore, approving the southern latitude of Spica as exactly $1^{\circ}59'$, we shall maintain that it has departed from the intended mark by nothing at all that can be discerned by any of the senses.

Accordingly, having carefully observed its declination, we shall establish the longitude by the following deduction.

On determining the longitude of Spica Virginis from its given latitude and declination

[De Longitudine Spicae ♍, ex data eius Latitudine & Declinatione praeфиниenda.]

Around the beginning of the year 1586 we obtained, from the heavens themselves, the meridian altitude of Spica (which they also call Arista) — with three or four large and skillfully made instruments capable of discerning even small fractions of minutes precisely — as $25^{\circ}8'55''$, with the testimony of the

several instruments agreeing. And since the altitude of the pole, deduced from the circumpolar stars (and especially from the Pole star itself, very carefully observed here many times), is $55^{\circ}54'45''$, and on this account the inclination toward the equator is $34^{\circ}5'15''$, as has often been indicated elsewhere — then, subtracting the altitude of Spica from the equatorial elevation of this place, the declination of the star comes out as $8^{\circ}56'20''$. From this declination and the latitude found earlier, we shall investigate the longitude by the following demonstration.

Diagram. A spherical (orthographic) figure showing the relationship of equator, ecliptic, and the solstitial colure for deriving Spica's longitude. In the accompanying figure, AMB is taken as the equator and D as its Antarctic pole. EMF is the ecliptic and H its southern pole. The circle ADHBF represents the solstitial colure, through which a quadrant is drawn from the pole of the equator down into the equator itself, DIL, and another from the pole of the ecliptic through the same point [Spica], HIK. It is plain that LI is the declination of Spica, and KI its latitude; from these two known quantities we shall arrive at knowledge of the longitude, that is, of the distance from the solstice or equinox, by means of a single triangle, DHI, given all its sides.

- A (left): A — point on the equator
- M (center-top): M — center / intersection
- B (right): B — point on the equator
- L (center): L — point on quadrant DIL (declination foot)
- K (center, below L): K — point on quadrant HIK (latitude foot)
- I (center, below K, marked with star): I — Spica
- D (lower left): D — Antarctic pole of the equator
- H (bottom): H — southern pole of the ecliptic
- E (left): E — point on the ecliptic EMF
- F (right): F — point on the ecliptic EMF

For DH is the distance between the poles of the zodiac and the equator, equal to the maximum declination of the ecliptic, which we have determined over several past years subtly and certainly as $23^{\circ}31\frac{1}{2}'$. Side DI is the complement of Spica's declination, $81^{\circ}3'40''$. Side HI is the complement of Spica's latitude, $88^{\circ}1'$. With these three so arranged, the angle IHD will be found with little labor by triangular calculation as $71^{\circ}56'35''$, which measures the distance of Spica from the winter-solstitial colure. This quadrant being taken away, its distance from the autumnal equinox — following the course of the ecliptic — will not be unknown:

18°3'25". And this was the longitude of Arista found in this way for the stated time.

If this be compared with the value gathered earlier from Vega [Lucida Vulturis], by way of intervening stars through distances and declinations, a very slight discrepancy is found. For the difference in right ascension between this star [Spica] and Vega is 169°51'25".

Adding the right ascension of Vega, previously established as 26°0½', yields the right ascension of Arista as 195°51'55". And conversely, to check this matter, the difference in right ascension between Vega and the bright star of the Vulture [clarae Vulturis Stellae — "the bright star of Vulture/Lyra," as shown above] is 93°22'58"; subtracted from the right ascension of Vega, this gives the right ascension of the Vulture star as 292°37'32". If we now take away from this the equatorial distance between Spica and the said Vulture star, which is 96°45'10", the remainder will be the right ascension of Spica Virginis, gathered in this way: 195°52'22" — which exceeds the former value of its ascension by 27". Taking, then, the mean of both [right ascensions] of Spica Virginis, we shall reckon the right ascension as 195°52½', which is also the value noted above. Applying to this the given declination, 8°56½', the corresponding longitude comes out as 18°3¾' Libra [♎]. This falls short of the longitude derived earlier — from declination and latitude — by an imperceptible amount.

It is therefore clear that, by reasoning in this way, the positions of the fixed stars have been arranged and bounded by us so carefully and reliably that I would venture to vouch that in these matters there is not even a deviation of half a minute, either short of or beyond precision. To what degree this has so far been attainable in any way, let those judge who have considered the science of astronomy and have looked more deeply into the magnitude and difficulty of the task proposed.

I have confirmed the same point by several methods besides: by collating many careful observations, through the Moon — observed by day, examined against the Sun, and at night compared with the stars — and that on several occasions both in the morning and in the evening, with the impediments of parallax and refraction removed, perhaps with greater certainty of observation and with more suitable instrumental means than the ancients had in a comparable undertaking.

I have also diligently explored the same in several lunar eclipses, with the place of the Moon corrected against the point diametrically opposite the Sun, and

compared with the neighboring fixed stars, applying at the same time a careful allowance for parallax and refraction.

And I have likewise tested the same many times by the meridian transits of the stars, the moment of time being noted and a more accurate solar position applied. In all this everything agreed as closely as possible, with only one or another minute of discrepancy now in this direction, now in that — a result, as was shown above, of those slippery and uncertain fractions, the very things on which the business of treating these matters by such reasonings depends. But as for how, by these and other procedures (of which I have already spoken), I examined the positions of the stars many times over, and what I found in them, I have no wish to recount here tediously, nor to set down any of those findings, lest the account of them grow too long in this place. These are to be reserved, by the favor of divine mercy, for the whole work of the restoration of astronomy. There it will be more convenient to treat them more fully and completely. Meanwhile, I have no doubt that, by the reasons already set forth, the positions of the fixed stars have been designated rightly and sufficiently, so that no scruple of ambiguity lurks in them that could meet the senses.

But before we proceed further, I should like to compare the observations of Copernicus on Spica

and of Werner, as well as one or two others, with respect to the same star, and to examine the positions deduced from them, so as to make plain whether or not they can be made to agree.

Copernicus, in *On the Revolutions of the Heavenly Spheres*, Book III, Chapter 2 (*Revolutionum Caelestium* Lib. 3, Cap. 2), reports that in the year 1525 he found the declination of Spica Virginis to be $8^{\circ}40'$. Assuming its latitude precisely as 2° , in accordance with the notation of the ancients, by a somewhat different demonstrative route — passing through right circles, in the manner most commonly used by the Arabs, yet far too involved and laborious, since the same can be accomplished (as we showed before) by means of a single triangle — he composed the longitude of Spica as $17^{\circ}21'$ Libra [$\cap$]. And from this he inferred the precession of the equinoxes, presupposing the difference of longitude — which from the first point of Aries [γ], which he assumed as a foundation, up to Spica in the Ptolemaic Table [Abacus] [is reckoned] — although this agrees less well with the heavens themselves.

Copernicus also says that ten years earlier he found the declination of the same Spica to be $8^{\circ}36'$, and he places its position at that time at $17^{\circ}14'$ Libra [$\underline{\Delta}$], using, as before, the same method of argument.

But since, around the altitude of the pole of his place, he erred by some few scruples (as was indicated in its proper place in the preceding chapter), the declinations of this star turned out somewhat differently than they could legitimately be gathered from his own altitudes (which we grant were exact). When these are accordingly called back to the anvil [recomputed] and examined according to the procedure of our demonstration, everything will be found, on the assumption of the earlier figure, to come out in the following way.

In the observation he made in the year 1515, with the truer elevation of the pole at Frauenburg in Prussia — long since explored by my instruments as $54^{\circ}22\frac{1}{2}'$ — applied, the declination of Spica is found to have been at that time $8^{\circ}33\frac{1}{4}'$, falling short of his own notation by $2\frac{3}{4}'$, by as much as is also wanting in the altitude of the pole. Applying now the true latitude of Spica found earlier, $1^{\circ}59'$, together with the truer maximum declination, the angle IHD will come, from the three known sides of triangle DHI, to

Diagram. A repetition of the spherical figure on p. 218 (the same lettering), used here to recompute Spica's longitude from the Copernican observations. The orthographic sphere shows the equator AMB, the ecliptic EMF, the solstitial colure through the cardinal points, and the two quadrants meeting at I (Spica): the declination quadrant (foot at L) and the latitude quadrant (foot at K). The triangle DHI is formed by D (Antarctic pole of the equator), H (southern pole of the ecliptic), and I (Spica).

- A (left): A — point on the equator
- F (upper right): F — point on the ecliptic
- B (right): B — point on the equator
- L (center): L — declination foot
- M (center): M — center / intersection
- K (center, below L): K — latitude foot
- I (center, marked with star): I — Spica
- E (left): E — point on the ecliptic
- D (lower left): D — Antarctic pole of the equator
- H (bottom): H — southern pole of the ecliptic

$72^{\circ}56\frac{1}{2}'$. And accordingly the distance of Spica from the autumnal equinox is $17^{\circ}3\frac{1}{2}'$ Libra [$\underline{\Delta}$], preceding the Copernican notation by very nearly a sixth part of one degree. But in the other observation, which he made in the year 1525 — limiting also the declination, since with him a few scruples are wanting in the elevation of the pole — that [declination] will be $8^{\circ}37'15''$. And hence, the rest being as before, the angle IHD comes out as $72^{\circ}46'$, and accordingly the longitude of Spica [is] in 17° [Libra].

by $17^{\circ}14'$ Libra, since it anticipates the Copernican entry by seven minutes [scrupula]. For his observation is not consistent and exact to within half a minute, or perhaps even to a whole minute. In reconciling these figures, then, I think I have made the more probable choice: taking Spica's longitude for the intermediate year 1520, holding to a value midway between the two observations, I have fixed it at $17^{\circ}8\frac{1}{2}'$ Libra. As far as one may gather the truth from these observations, this will come closest. And so, traced from that time down to the completed year 1585 — an interval of 65 years — Spica will be found to have advanced, together with the rest of the fixed stars, by $55'$, very nearly; and even this does not depart greatly from the truth, as will be shown elsewhere. So much for what concerns the Copernican observations of Spica.

Now I wish to examine Werner's observations as well, and to compare them with these and with my own.

Johann Werner [Johann Werner] of Nuremberg, in that little work which he entitled *On the Motion of the Eighth Sphere* — would that it were as true as it is ingenious and profound! — sets out the declinations of three fixed stars, found by him through observation at Nuremberg, by means of the Ptolemaic rules. He gives Regulus [Basiliscus] at $14^{\circ}7\frac{1}{2}'$; Spica at $8^{\circ}29\frac{3}{4}'$; the Southern Pan of the Balance [Meridionalis Lancis Librae] at $13^{\circ}38\frac{1}{2}'$. From these declinations, presupposing for these stars the same latitudes that the ancients had assigned them, in his Second Proposition he investigates their longitudes by a method still more concise than the one Copernicus had used for Spica. He places the Heart of Leo [Cor Leonis, Regulus] at $22^{\circ}42'$ Leo; Spica at $16^{\circ}53\frac{1}{4}'$ Libra; but the Southern Pan at $8^{\circ}14'$ Scorpio. This determination of the longitudes agrees well enough with mine — by means of the single triangulation-reckoning indicated above for Spica, applied to these given data — except that in the Heart of Leo about one minute is wanting, and in the Southern Pan one minute is in excess; which in itself is of no great moment. In Spica itself they agree to the second [of arc]. And all this falls about the year of Christ 1515.

But when Werner derives, from his own observations, these same differences of longitude between the Heart of Leo and Spica, and this more southerly Pan, such as the Ptolemaic and ancient canons exhibit, then — whereas in the sky they are actually distant from one another, in longitude, by $54^{\circ}10'$ between the Heart of Leo and Spica — he sets them at about $53^{\circ}59'$; and whereas from Spica to the Pan of the Balance the heavens show $21^{\circ}20'$, he sets them at $21^{\circ}14'$. One may not unjustly suspect that he simply fabricated these declinations as he pleased, without any sound observation, so that with the ancient latitudes assumed, the differences of those same longitudes would agree with them. I am astonished that a man otherwise serious and truthful was willing, in so difficult and necessary a matter, to engage in such a business — so that there is no longer any question why that most learned mathematician Pedro Nunes [Pedro Nunes] the Spaniard, in his work on navigation, was unable to reconcile the Copernican and the Wernerian observation of Spica: for Copernicus's record rests upon a fairly careful celestial observation — except that he did not apply the correct pole-altitude — whereas Werner's, as may be gathered from what has been said, was composed merely conjecturally and at will.

Werner, moreover, did not here apply the exact pole-altitude of the city of Nuremberg, but assumed it to be $49^{\circ}23\frac{1}{2}'$, and that — through observation made at both solstices by the Sun, no doubt — was liable to the very error I sufficiently demonstrated in Chapter 1. If therefore we reduce these to the truer elevation of that city's pole, which I investigated there by careful collection at $49^{\circ}26'$, the declination of the Heart of Leo will come out as $14^{\circ}10'$; and with its latitude applied — which I found from the sky to be $0^{\circ}26\frac{1}{2}'$ — its longitude will yield $23^{\circ}27'$ Leo, following the same tenor of demonstration I used above for Spica, except that here the quadrants drawn through the star to the ecliptic and the equator proceed from each of their poles, the northern one, while in the other cases they are taken alike.

Thus the declination of Spica of Virgo will now be $8^{\circ}27'$, and with its truer latitude of $1^{\circ}59'$ applied, the longitude will come out at $16^{\circ}47\frac{3}{4}'$ Libra.

But the declination of the Southern Pan will come out by this reasoning as $13^{\circ}36'$; and this, taken together with its latitude as observed from the sky, $0^{\circ}25\frac{1}{2}'$, in the same way as was done with Spica, examined demonstratively by the numbers, places the longitude of the Southern Pan at $7^{\circ}19'$ Scorpio.

And all this so plainly disagrees, both with Werner's own composition of numbers and even more with the sky itself, that it is the more evident he indulged his own judgment too freely and obtruded upon us, in place of a

celestial observation, his own arbitrary preference — a thing that ought indeed to be utterly foreign to the office of an astronomer.

If the truer positions of these three stars, which I have deduced from the sky itself by my reckoning for about the beginning of the year 1515, are compared with his, an evident and intolerable discrepancy will be found.

And so that all this may be set before the eyes, I shall lay before you a brief little table of Werner's, both as drawn from his own *Dedomena* [given data], and as limited by my correction of the pole-altitude of his locality, with the true latitudes of the stars assumed and an emendation of those same latitudes, together with their positions advanced, according to my restitution, up to that same point.

Comparison of three stars — Regulus [Basiliscus], Spica [Arista], and the Southern Pan of the Balance — from the annotation of Johann Werner, set out in a twofold manner, and directed by my restitution, the individual values referred to the beginning of the year 1515.

[Source caption: *COLLATIO TRIVM STELLARVM, BASILISCI, ARISTAE, ET MERIdionalis Lancis* ♄, è IOHANNIS VVERNERI annotatione, duplici modo proposita, nostraq; restitutione, singulis ad Annum 1515 inchoantem directa.]

Names of the stars	Ex propria Weneri collectione (From Werner's own collection)	—	Ex nostra correctione in Wenero (From my correction in Werner)	—	Iuxta propriam Stellarum verificat. (According to my own verificatio n of the stars) —	—
	— Longit. P. /	Latitud . P. /	— Longit. P. /	Latitud . P. /	Longit. P. /	Latitud . P. /
Regulus	22 / 43	0 / 10 B.	23 / 27 ♄	0 / 26½	23 / 4 ♄	0 / 26½ B.
Arista [Spica]	16 / 53 ♄	2 / 0 M.	16 / 47 [♄]	1 / 59	17 / 3 ♄	1 / 59 M.
Mer. lanx ♄ [Southern Pan]	8 / 13 ♄	0 / 40 B.	7 / 19 ♄	0 / 25½	8 / 18 ♄	0 / 25½ S.

And from these things it is sufficiently clear, if one looks more carefully into them, that Werner's annotations — which he set, as it were, as a foundation for his treatment of the motion of the eighth sphere — are inconsistent both among themselves and with the sky itself, and that nothing certain can be concluded from them.

For as concerns Spica, by comparison with my observations, it makes the motion of the eighth sphere too rapid; whereas the Copernican observation, made about the same time on this very star in the year 1515, when compared — with the truer polar elevation of its locality and with the star's latitude corrected — agrees with my rectification almost to the very minute.

But through the Heart of Leo, if its altitude observed in my fashion is examined more correctly, it makes the motion of the fixed stars too slow up to now.

And from the more southerly Pan of the Balance a still greater motion is induced than from Spica, so that all these things are entirely at odds with one another.

And from this it appears how much credit Werner's observations deserve — which he reports himself to have made from the sky — and how, in this matter, the Copernican record concerning Spica of Virgo is rather the one to be relied upon.

Nevertheless, I do not bring up these reflections on Werner's positions in order to diminish the memory and honor of that distinguished man, who deserved well not only in astronomical and astrological matters but above all in geometry, and who is in every way most worthy of all praise and remembrance. But because my purpose is to draw out into the open the exact truth concerning the dispositions and advancements of the fixed stars — wrapped in darkness until now — and because I judged it worth the effort to set these things forth, lest the authority of so great an astronomer, who seems to have undertaken this subject professedly, adorned moreover with subtle geometrical demonstrations, should present to the unwary the sought-for center as eccentric: I have judged it worth while to set these matters forth and to leave the rest to be judged by others.

Therefore, since it is sufficiently and more than sufficiently clear from the foregoing that not only that bright star of Virgo, but also all the rest which I assumed as a foundation for restoring the others, agree rightly in every part — and that the criticisms of others detract nothing from mine in this regard — I now wish to indicate briefly by what method I have arranged the others, from these, in their proper place according to longitude and latitude. And I shall do this by taking, in each of the single twelve-parts [Dodecatemoria] of the zodiac, some one star which

will serve the rest as an example, so that it may be made known by what method and with how great diligence I have, conversely, verified the positions of the fixed stars.

This method of rectification, which I shall append in a moment, holds chiefly for those stars whose positions lie around the equator and the zodiac, contained within the middle belt of the heavens, and which exhibit the same course, as it were, with respect to the equator — so disposed that they run not directly toward its poles, but rather obliquely, as though parallel to the equator, or nearly so (for it does not matter if they have a somewhat different distance from the equator, or even if they are placed in different regions with respect to it). For the rest of the stars, which are nearer to the poles, I employed another and more laborious practice of verification — namely, by means of the distance of one unknown star to two or three others already known beforehand, carrying out the matter by triangulation. Just as in the stars of Cassiopeia [Cassiopeia], which by this method I largely succeeded in restoring to their proper place, as will appear later on.

The manner, then, in which I have reduced the stars placed here and there throughout the middle belt of the heavens to a position exact and consonant with the sky itself, is as follows.

I observed each unknown star from two others set on either side, one here, one there, already verified beforehand — two distances, together with the same star's declination. From these, having assumed the right ascensions and declinations of the known stars, already determined earlier, I sought out the right ascension of this unknown star from both, according to the reckonings shown above. And so, having obtained two right ascensions of one and the same star, if they fell upon the same value, I kept that very one which both yielded in agreement. But if some tiny difference intervened (for it cannot be large, if the observation is rightly established), then half of it [I assigned] to the lesser...

added to the smaller Right Ascension, or subtracted from the larger, this revealed without any hesitation the exact Right Ascension of the star in question.

In this way, whenever I undertook these observations with the equatorial armillae, I explored the difference of ascension from one side and the other—twice over, in fact, in cases where a single star was not directly determined but had to be interpolated between two known marks—and conversely I confirmed its Right Ascension, limiting it, where necessary, by the procedure just described. For here there is no need to compute the angle of the difference of ascension from three given sides, since the instrument of the equatorial armillae itself

displays this angle—which is the same as the difference of equatorial ascension—on a more generous scale during the observation. Indeed, the same armilla shows the Declination of the star with the least trouble, whether it stands on the Meridian or off it. Otherwise the declination would have to be measured by the Quadrant from the Meridian altitude, with the inclination of the equator brought in, or—off the Meridian—from a given altitude together with the azimuth; and that method is far more involved and less reliable.

Therefore, once the Right Ascension and Declination of any star have been found by the help of one or another of these methods, it is not difficult to determine that star's Longitude and Latitude with respect to the Ecliptic, following the method I have used before in a similar task, since the whole business can be accomplished by means of a single triangle.

But to avoid the need for a tedious and lengthy computation in this part every time, I had a certain Table constructed at no small labor, from which—given the declination and Right Ascension—one may immediately extract the Longitude and Latitude of any star. For each single degree of Right

Ascension throughout the whole circuit of the Equator, and for Declinations of up to 32 degrees of distance from the Equator on either side, this Table assigns the Longitudes and Latitudes—not merely in degrees and first minutes, but in seconds as well—on the assumption (which I myself have devised) of the greatest mutual obliquity of the Equator and the Ecliptic.

This Table, however, was put together at the cost of no little time. I shall publish it on another occasion, when, God willing, I treat in a separate volume of the construction and use of my instruments, together with many other matters thoroughly suited to the practice of observations, and I shall communicate it readily and generously toward the intended end.

For now I shall set out, by way of example, what pertains to certain stars belonging to the several constellations of the Zodiac, presenting it briefly and in a concise order so that it may be readily grasped and surveyed.

VERIFICATION OF TWELVE STARS

The verification of twelve stars—one from each of the constellations of the Zodiac—with respect to Longitude and Latitude, by the method I customarily use, so that they may serve as an example for the rest that lie around the middle circuit of the Heaven [circa Coeli medium Ambitum].

I.

The First Star of Aries [Prima Arietis]

We shall begin with the First Star of Aries [Aries Υ], which Copernicus [Copernicus] employed so heavily, deducing from it the Longitudes not only of all the fixed stars but of the wandering stars as well—taking it, together with the rest of the fixed stars, to be entirely motionless, while only the equinoctial points recede into the antecedent signs, and that unevenly, so that by this account he might excuse the irregularity of the motion of the Eighth Sphere [sphaera octava] found from the comparison of many centuries. But on this matter we shall set out our

own opinion elsewhere. Now we determine the true distance of this First Star of Aries—which is the more forward one, in the right horn of that figure, barely of the third magnitude—from the equinox, together with its Latitude, according to our own reckonings, and we do so from two stars placed on either side of it. First, toward the antecedent direction, from the First Star of the Wing of Pegasus [Prima Alae Pegasi], whose Declination for the completed year 1585 is $13^{\circ}.0\frac{2}{3}'$ North, and from which the First Star of Aries is found by Observation to be distant $40^{\circ}.23\frac{1}{2}'$. On the other side, in the direction of the consequent signs, from the Eye of Taurus [Oculus Tauri Υ], whose Declination at that time was $15^{\circ}.36\frac{1}{4}'$ North, and from which the same First Star of Aries is found to be removed $38^{\circ}.39'$. The Declination of the assumed star itself in Aries was, at the said time, $17^{\circ}.14'$ North.

From these data, since the Declinations of all three stars, and their distances from one another, are settled, it will be a most straightforward matter to gather the differences of ascension of any two of them, by that mode of demonstration repeated several times above. The difference of ascension of the First Star of Aries from the First Star of the Wing of Pegasus comes out as $41^{\circ}.41\frac{1}{4}'$. This, added to the Right Ascension of the First Star of the Wing found earlier, which was $341^{\circ}.2\frac{1}{2}'$, yields the Right Ascension of the First Star of Aries as $22^{\circ}.43'.50''$. Conversely, in confirming this, the difference of ascension from Aldebaran [Aldebaran] is found to be $40^{\circ}.19\frac{3}{4}'$; and if this is subtracted from the Right Ascension of the Eye of Taurus, also disclosed earlier as $63^{\circ}.3\frac{3}{4}'$, it leaves the Right Ascension of the star we are treating, gathered with respect to Aldebaran, as exactly $22^{\circ}.44'$. Now if these two Right Ascensions, derived from either side, are compared with each other, the difference between them is found to be a sixth part of one minute at most; so that, examined in both directions and thus

delimited, the Right Ascension of the First Star in the constellation Aries is confirmed without any doubt, by the procedure proposed, as $22^{\circ}.43'.55''$.

To this corrected Right Ascension, if we apply the Declination of the same star, we shall forge from both its true position with respect to Longitude and Latitude relative to the Ecliptic. This may be carried out, if one wishes, by the triangular computation indicated above, by means of a single triangle, with sufficient brevity; or else by drawing the very same result, with a still readier reckoning, from the Table constructed by us for this purpose. The Longitude of this star—which is the first in Aries—will be found, or what amounts to the same thing, its distance from the Vernal equinox, to be very nearly $27^{\circ}.24'$ of Aries, together with a Latitude of $7^{\circ}.8\frac{1}{2}'$ North. These are the two things we have set ourselves to make known by this process of reasoning.

Here, however, I cannot pass on without warning those eager for Astronomy why it has come about that the great Copernicus arranged the distance of this star from the Vernal equinox so enormously, since he wished the whole reckoning to rest on it alone, so that from it (as we have said) he undertook to deduce the places of all the others, both the wandering and the fixed.

For it is gathered from his own Calculation that the Longitude of this star, for the completed year 1585, is about $27^{\circ}.57'$ of Aries—which is also the true Precession of the equinoxes, as he so names it—while, adhering to the Ptolemaic Abacus, he sets its Latitude at $7^{\circ}.20'$. And so, in this star's Longitude, there is an excess of $33'$ in Copernicus, and in its Latitude an excess increased by a fifth part of a degree, again in imitation of Ptolemy [Ptolemy]. But the reason Copernicus deviated so greatly in fixing this star's Longitude is not that he measured it from the heavens less correctly by any peculiar Observation of his own. Rather, it was from Spica [Spica] of Virgo—which he supposed he had correctly determined in the year 1525 (a matter we have discussed above)—that he subtracted the zodiacal interval in Longitude which, according to the Ptolemaic Abacus, is gathered to be exactly 5 signs 20 degrees, taking it away from the Longitude of Spica he had found, and thus arranged his First Star of Aries, relying too much on the Ptolemaic interval with respect to Spica.

Since, therefore, this First Star of Aries and Spica of Virgo really do stand, in the heaven itself, at a distance in Longitude of 5 signs $20^{\circ}.39'$, it should not seem surprising to anyone applying due diligence that, the Ptolemaic interval falling short of the truth by nearly two-thirds of one degree, Copernicus—relying on it—deviated by almost as much from the intended target in designating this star's Longitude, falling short by at least six minutes. And this happened because, in

these matters, he had gathered the Longitude of Spica of Virgo too high, beyond what his own Observation warranted (as has been disclosed above in its place).

And this was the cause why so great a man went so plainly astray in correctly determining this star.

Yet not on that account does this same enormous discrepancy carry over to the places of all the remaining stars and the planets, which he deduces from this assumed starting point. For in deriving the equinoctial Precession from Spica of Virgo to this point, he could go astray in establishing this Precession only to the extent that the position of Spica itself deceived him—which was not by much, not exceeding a twelfth part of a degree—so that the First Star of Aries is presupposed, by his reckonings, to be a little more than half a degree more forward than the Ptolemaic table (which he used) makes it, as measured from Spica of Virgo, he himself not taking this into account. Let it suffice to have noted and shown this much here concerning the Copernican determinations regarding the First Star of Aries. Now we shall go through the places of the stars in all twelve constellations by the same method we have used in the case of this First Star of Aries.

But so as not to repeat the whole procedure so often and so wearisomely—obscuring the matter itself by excessive prolixity rather than explaining it—we shall now set out in order the chief Terms of this Practice, with a brief indication.

The following six tables present, for six pairings of zodiacal asterisms, the verification triplet of stars (each headed by the constellation in which the principal star lies). The columns are: the star's name/description; its declination (P. = degrees, then minutes, with B. = north [Borealis] or M. = south [Meridionalis]); the mutual distance between the stars [Distantia ad invicem]; the difference of ascension [Differentia Ascensionis]; the right ascension on both sides [Ascensio recta utraque]; the limited right ascension [Ascensio recta limitata], marked R.; and finally the resulting longitude and latitude referred to the ecliptic.

I. In ♈ (Aries), the First Star of Aries [Prima Arietis]

Nomina stellarum	Decl. harum (P. B. ')	Distant. ad invicem (P. ')	Differ. Ascens. (P. ')	Asc. R. utraque (P. ')	Asc. R. limitat. (P. ')	Longitudo / Latitudo (P. ')
Pri. Al. Peg.	13 0 $\frac{2}{3}$	40 23 $\frac{1}{2}$	41 41 $\frac{1}{3}$	22 43 $\frac{5}{6}$	—	—

Nomina stellarum	Decl. harum (P. B. °)	Distant. ad invicem (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitat. (P. °)	Longitudo / Latitudo (P. °)
[First of the Wing of Pegasus]						
Prima γ [First Star of Aries]	17 14	38 39	40 19¾	22 44	22 44 R.	Lon. 27 24 γ / Lat. 7 8½ B.
Aldebora [Aldebaran]	15 36¼	—	—	—	—	—

II. In ♂ (Taurus), the Northern Eye [Borealis Oculus]

Nomina stellarum	Decl. (P. B. °)	Distant. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitat. (P. °)	Longitudo / Latitudo (P. °)
Lucida γ [Bright Star of Aries]	21 28½	33 8½	35 8	61 8½	—	—
Bor. Ocul. ♂ [Northern Eye of Taurus]	18 12	30 48	32 17	61 7⅔	61 8 R.	Lon. 2 40 II / Lat. 2 36½ M.
Lucid ⁹ pes II [Bright Foot of Gemini]	16 40⅓	—	—	—	—	—

III. In ♊ (Gemini), the Bright Foot [Lucida pedum]

Nomina stellarum	Decl. (P. B. °)	Distan t. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitat. (P. °)	Longitudo / Latitudo (P. °)
Aldebora [Aldebara n]	15 36¼	29 9	30 21¼	93 25	—	—
Lucid. pes ♊ [Bright Foot of Gemini]	16 40⅓	51 11	53 8½	93 24¼	93 24⅔ R.	Lon. 2 18 ♊ / Lat. 6 48⅓ M.
Cor Leonis [Heart of Leo / Regulus]	13 57¾	—	—	—	—	—

III. In ♋ (Cancer), the Northern Ass [Asellus Boreus]

Nomina stellarum	Decl. (P. B. °)	Distan t. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitat. (P. °)	Longitudo / Latitudo (P. °)
Lucid ⁹ pes ♊ [Bright Foot of Gemini]	16 40⅓	30 4½	31 20⅓	124 45	—	—
Asellus Bor. [Northern Ass]	22 52½	22 29½	21 48	124 44	124 44⅔ R.	Lon. 1 44 ♋ / Latit. 3 7 B.
Cor Leonis [Regulus]	13 57¾	—	—	—	—	—

V. In ♌ (Leo), the Bright Star of the Neck [Lucida Colli]

Nomina stellarum	Decl. (P. B. °)	Distan t. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitat. (P. °)	Longitudo / Latitudo (P. °)
Infer. cap. ♌ [Lower	28 57	35 59	39 15½	149 13½	—	—

Nomina stellarum	Decl. (P. B. ')	Distan t. (P. ')	Differ. Ascens. (P. ')	Asc. R. utraque (P. ')	Asc. R. limitat. (P. ')	Longitudo / Latitudo (P. ')
of the Head of Gemini]						
Luc. Colli ♌ [Bright Star of the Neck of Leo]	21 54½	40 3¼	41 8½	149 13	149 13¼ R.	Lon. 23 46 ♌ / Latit. 8 47 B.
Vindemiati or [Vindemia trix]	13 13½	—	—	—	—	—

VI. In ♍ (Virgo), the Third Star of the Southern Wing [Tertia Australis Alae]

Nomina stellarum	Decl. (P. B. ')	Distan t. (P. ')	Differ. Ascens. (P. ')	Asc. R. utraque (P. ')	Asc. R. limitat. (P. ')	Longitudo / Latitudo (P. ')
Cor Leonis [Regulus]	13 57¾	40 22	38 35¾	185 8½	—	—
Ter. aus. al. ♍ [Third of the Southern Wing of Virgo]	0 51¼	14 29¼	10 43½	185 8⅓	185 8½ R.	Lon. 4 22½ ♍ / Latit. 3 50 B.
Spica ♍ [Spica]	8 M 56⅓	—	—	—	—	—

On this page the declination column header reads "Declinatio" with subscript P. M. ' (M. = south [Meridionalis]); B. still marks individual north readings where they occur.

VII. In ♎ (Libra), the Northern Pan of the Balance [Lanx Borealis]

Nomina stellarum	Declinatio (P. M. °)	Distant. ad invicem (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Spica ♏ [Spica]	8 56 $\frac{1}{3}$	27 34	27 50 $\frac{1}{2}$	223 42 $\frac{3}{4}$	—	—
Lanx Bor. ♎ [Northern Pan of Libra]	7 45 $\frac{3}{4}$	24 10 $\frac{1}{2}$	17 21 $\frac{1}{2}$	223 43 $\frac{1}{6}$	223 43 R.	Lon. 13 35 $\frac{1}{4}$ ♏ / Latit. 8 35 B.
Cor ♏ [Heart of Scorpio / Antares]	25 23	—	—	—	—	—

VIII. In ♏ (Scorpio), the Heart, or Antares [Cor sive Antares]

Nomina stellarum	Declinatio (P. M. °)	Distant. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Borealis lanx [Northern Pan]	7 45 $\frac{3}{4}$	24 10 $\frac{1}{2}$	17 21 $\frac{1}{3}$	241 4 $\frac{1}{3}$	—	—
Cor ♏ [Antares]	25 23	35 37 $\frac{1}{2}$	38 55	241 5	241 4 $\frac{2}{3}$ R.	Lon. 4 0 ♂ / Latit. 4 27 M.
Med. cap. ♂ [Middle of the Head of Sagittarius]	22 13	—	—	—	—	—

IX. In ♐ (Sagittarius), the Middle of the Head [Media Capitis]

Nomina stellarum	Declinatio (P. M. °)	Distantia (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Dext. hum. ♊ [Right Shoulder of Aquarius]	2 16⅓	48 59⅓	46 7	280 0½	—	—
Med. Cap. ♐ [Middle of the Head of Sagittarius]	22 13	35 37½	38 55	279 59⅓	280 0 R.	Lon. 9 15 ⅓ / Lat. 0 59 B.
Cor ♋ [Antares]	25 23	—	—	—	—	—

X. In ♑ (Capricorn), the Preceding of the Two in the Tail [Praecedens duarum in cauda]

Nomina stellarum	Declinatio (P. M. °)	Distantia (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Supe. Corn. ♑ [Upper Horn of Capricorn]	13 42	20 15¾	20 31½	319 15⅓	—	—
Prec. caud. ♑ [Preceding of the Tail of Capricorn]	18 24½	38 3½	21 47⅓	319 15⅛	319 15½ R.	Lon. 16 1 ⅓ / Latit. 2 26 M.

Nomina stellarum	Declinatio (P. M. °)	Distantia (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Pri. Alae Peg. [First of the Wing of Pegasus]	13 B. 0 $\frac{2}{3}$	—	—	—	—	—

XI. In ♒ (Aquarius), the Left Shoulder [Sinister humerus]

Nomina stellarum	Declinatio (P. B. °)	Distantia (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Lucida Vult. [Bright Star of the Vulture / Vega]	7 51 $\frac{1}{2}$	29 0 $\frac{1}{2}$	24 47 $\frac{1}{3}$	317 24 $\frac{2}{3}$	—	—
Sin. hum. ♒ [Left Shoulder of Aquarius]	7 M. 18 $\frac{1}{4}$	31 3 $\frac{3}{4}$	23 38 $\frac{1}{2}$	317 24	317 24 $\frac{1}{3}$ R.	Lon. 17 38 ♒ / Latit. 8 42 B.
Pr. Alae Peg. [First of the Wing of Pegasus]	13 B. 0 $\frac{2}{3}$	—	—	—	—	—

XII. In ♓ (Pisces), the Bright Star in the Knot of the Threads [Lucida in nexu linorum]

Nomina stellarum	Declinatio (P. B. °)	Distantia (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
Pr. Alae Peg. [First	13 0 $\frac{2}{3}$	43 23	44 7 $\frac{1}{6}$	25 9 $\frac{2}{3}$	—	—

Nomina stellarum	Declinati o (P. B. °)	Distan t. (P. °)	Differ. Ascens. (P. °)	Asc. R. utraque (P. °)	Asc. R. limitata (P. °)	Longitudo / Latitudo (P. °)
of the Wing of Pegasus]						
Luc. in nex. l. [Bright Star in the Knot of the Threads]	0 44½	40 13¾	37 53¾	25 10	25 9⅝ R.	Lon. 23 34⅔ ° / Lat. 9 4½ M.
Aldebora [Aldebara n]	15 36¼	—	—	—	—	—

In this way we have verified not only these stars, but all the others visible throughout the whole zodiac, and a great many around the equator besides — indeed the entire principal and middle belt of the heavens — for which we shall at last give the catalogue and its canonical exposition.

So that these twelve stars, restored each within its individual zodiacal asterism, may be more readily seen at a glance, I shall set them out in the table below — showing their true positions all at once, to be known both with respect to the equator and to the ecliptic — and shall mix in nine others alongside them, established above with no less care. In this way, by means of these twenty-one stars, accurately fixed here and there throughout the whole circuit of the heavens around every zodiacal asterism, it will be possible to deduce from the heavens the positions and apparent places not only of the remaining fixed stars but also of the planets in the zodiac, wherever in their courses they may happen to be — and that with ready and minimal labor, and with assured certainty too — by anyone who investigates celestial matters (should any such arise). It will also be possible to test plainly how great an injury every calculation hitherto employed in astronomy inflicts on the heavens themselves by its own departure from them.

Now, therefore, I shall record the stars summarily comprehended in the following table, in the order in which they follow one another and as they come to be arranged in their proper places through this modern correction, their

positions adapted to the year already stated — from which they can easily be reduced to any other year.

** Tabella [The Table]

A table presenting the true positions of 21 particular stars, placed here and there throughout the individual zodiacal asterisms, both with respect to the equator and to the ecliptic, deduced from the heavens for the completed year 1585 — so that from these the apparent positions of the remaining fixed stars, and also of the planets, may be observed wherever they may be in their courses.

The grid is divided into two double-columns: **Ad Aequatorem** (to the equator) giving Declinatio (P. = degrees, ' = minutes, with B. north / A. = *Australis* south) and Ascensio recta (P. '); and **Ad Eclipticam** (to the ecliptic) giving Longitudo (P., then ' followed by the zodiac-sign glyph) and Latitudo (P. ', with S. = south / M. ambiguously also used for south, B. north).

Nomina stellarum	Dec l. P	Decl. '	Ascens. R. P	Ascens. R. '	Lo ng. P	Long. ' + sign	La t. P	Lat. '
Prima Υ [First Star of Aries]	17	14 B.	22	44	27	24 Υ	7	8½ S.
Lucida Arietis [Bright Star of Aries]	21	28½ B.	26	0½	1	53 γ	9	57 S.
Bor. Oculus γ [Northern Eye of Taurus]	18	12 B.	61	8	2	40 Π	2	36½ M.
Aldebora [Aldebaran]	15	36¼ B.	63	3¾	4	0 Π	5	31 M.
Calx pedis Π [Heel of the Foot of Gemini]	22	38½ B.	89	29½	29	31½ Π	0	53 M.
Lucidus pes Π [Bright Foot of Gemini]	16	40½ B.	93	24¾	3	18 $\mathfrak{S}$	6	48½ M.
Pollux	28	57¾ B.	109	58	17	30½ $\mathfrak{S}$	6	38 S.

Nomina stellarum	Dec l. P	Decl. ' B.	Ascens. R. P	Ascens. R. ' B.	Longitude. P	Long. ' + sign	Latitude. P	Lat. ' S.
Asellus Boreus [Northern Ass]	22	52½ B.	124	44⅔	1	44 ♏	3	7 S.
Lucida colli ♏ [Bright Star of the Neck of Leo]	21	54½ B.	149	13¼	23	46 ♏	8	47 S.
Regulus	13	57¾ B.	146	32¾	24	4⅔ ♏	0	26½ S.
Tertia Aust. Alae ♍ [Third Star of the Southern Wing of Virgo]	0	51¼ B.	185	8½	4	22½ ♍	2	50 S.
Arista [Spica]	8	56⅓ A.	195	52⅓	18	3 ♎	1	59 M.
Lanx Borealis ♎ [Northern Pan of Libra]	7	45¾ A.	223	45	13	35¼ ♍	8	35 S.
Bor. manus Ophiuchi [Northern Hand of Ophiuchus]	2	33¼ A.	238	11⅓	26	31 ♎	17	20 S.
Cor Scorpii [Heart of Scorpio / Antares]	25	23 A.	241	4⅔	4	0 ♏	4	27 M.
Med. Capitis ♏ [Middle of the Head of Sagittarius]	22	13 A.	280	0	9	15 ♏	0	59 S.
Aquila [Aquila / Altair]	7	51⅓ B.	292	37⅓	25	56 ♏	29	21½ S.
Praeced. caudae ♏ [Preceding of the Tail of Capricorn]	18	24½ A.	319	15½	16	1 ♎	2	26 M.

Nomina stellarum	Dec l. P	Decl. '	Ascens. R. P	Ascens. R. '	Lo ng. P	Long. ' + sign	La t. P	Lat. '
Sinist. hum. ♊ [Left Shoulder of Aquarius]	7	18¼ A.	317	24⅓	17	38 ♊	8	42 S.
Prima Alae Pegasi [First of the Wing of Pegasus]	13	0¾ B.	341	2½	17	44 ♋	19	26 S.
Luc. in connexu ♋ [Bright Star in the Knot of Pisces]	0	44½ B.	25	9⅝	23	34⅔ ♋	9	4½ M.

With these matters settled, the next step would rightly be to present the corrected positions of a larger number of stars determined by us — both by the preceding method and by other indubitable reasonings — and to set them out in canonical fashion, with their places in the Zodiac as well as on either side outside it. In truth, however, concerning the latitudes of the stars, which have hitherto been believed unchangeable, something special has come to light that was not explored by our predecessors, and which must necessarily be made plain here. I consider it worthwhile to treat of this first; then to give a description of the instruments on which I have chiefly relied in these observations, especially those whose drawings and engravings I now have at hand, setting out the construction of each one. Finally I shall present the table [Abacus] of stars verified by us — though prefaced by the reasoning by which I have decided to arrange the positions of the fixed stars, derived by their annual motion, for any time within the nearest three or four centuries, and reduced and predetermined from those positions completed for the year 1600. Let me therefore now take up these matters in the order just stated.

That the fixed stars change their latitudes, in proportion to the variation in the obliquity of the ecliptic, as shown by comparing the observations of Timocharis, Hipparchus, and Ptolemy with our own.

From observing that some stars — even among the principal ones, those most carefully observed by the ancients — have shifted their latitudes quite perceptibly (those latitudes hitherto believed to be perpetually fixed), I began to weigh with myself how this could have happened. At last, after instituting a comparison of many of them, I found by reasoning that it comes about through the changed obliquity of the ecliptic. For among those stars that are nearer the tropics, a greater difference was found than among those that lie between the equinoctial and solstitial points. The least difference of all — scarcely perceptible — is in those that stand at the equinoctial points; and this is very nearly in the same proportion of variation as the changed inclination of the ecliptic to the equator has required from the times of the ancients down to the present.

Since this is a matter of great importance — and, so far as I know, not noticed before by others, and one that contributes much to fitting the positions of the fixed stars accurately to each age of the world — I have investigated the business by a deeper inquiry. I have not relied solely on the Ptolemaic latitudes recorded in his own table, which for the most part are erroneous (whether this happened through the author's carelessness or that of the copyists, I will not say), but I have used a special procedure: from several

stars whose declinations were marked out by Timocharis, Hipparchus, and Ptolemy — the same ones that Ptolemy reviews in Book 7, Chapter 3 of his *Almagest* (*Almagest* VII.3) — and applying the longitudes they then had, I searched out the latitudes nearest to the truth and compared them with our own observations.

As for the longitudes of the stars as they stood in their own age, I investigated these from the declination of Spica Virginis (which they assigned). Having thus gathered the interval of longitude — that is, how far they had advanced in the time elapsed — and having applied this same difference of longitude (which even now is found to hold with respect to Spica Virginis, from my observations), I obtained the result. For that the distances of the stars, or their mutual differences of longitude, are not variable, the experience of very many centuries has made us certain. And even if there were nothing else to attest this clearly, surely the very stars that Ptolemy records as having stood, in the time of Hipparchus and his

own, in a single straight line — or nearly so — and as remaining still in the same arrangement, exactly unchanged so far as the run of the straight line goes, prove the matter sufficiently and more. They prove that things stand thus even though now nearly two thousand years have passed since Hipparchus.

And since some will perhaps be found who are too bold in presuming to deny this, I shall, before we proceed to what we intend, enumerate certain of those stars which in the time of Hipparchus and Ptolemy stood in a direct line, or very nearly, and which even now remain so — not, as I see, without good reason. First I shall undertake to draw this matter out from Hipparchus.

Hipparchus asserted that the head of Pegasus, and the dimmer star on its forehead, lie in one straight line with the preceding shoulder of Aquarius; this still holds in the same way now.

Thus a line drawn from the right shoulder of Aquarius to the first star of the Wing of Pegasus leaves the Bright Star of its Neck somewhat toward the west, just as it did then.

A straight line described over the Muzzle of Pegasus, and the fourth star in the hand of Aquarius — which is to the east and is number twelve — still cuts two others in the Head of Pegasus at right angles, just as in Hipparchus's age.

Thus the First Star of Piscis Austrinus, and the First of the Wing of Pegasus, together with Scheat, are even now in a single direct alignment, as in the time of Hipparchus.

A line descending from the lower [star], or the Bright Star in the foot of Andromeda, to the Bright Star above the Head of Aries [V] falls — somewhat brighter — upon Deltoton [the star] at the base [of the triangle], a little toward the east, just as it appeared to Hipparchus too.

An arc drawn out from the Bright Star of Vultur [Lyra] to Fomalhaut cut for him the two stars in the tail [of Capricorn] [?], as it were equally — yet so as to incline somewhat more toward the preceding one; which is still evident now.

Not otherwise does a line from the same Fomalhaut to the Muzzle of Pegasus, drawn from the brighter star in the following shoulder of Aquarius, decline about half a degree, very nearly, toward the west — which is also evident to the eye itself.

Moreover, a line from this same Fomalhaut to the Muzzle of the Fish of the South [Piscis Austrinus] falls directly upon the first star of the Wing of Pegasus, with Scheat declining a little toward the west, just as Hipparchus also noted.

And let these things from the Hipparchian considerations suffice. Now I shall add certain Ptolemaic examples.

When a rule is applied from Lyra to the lower star in the Horn of Capricorn, the upper one in the same Horn comes out a little more to the east, and the star of Vultur [Lyra] recedes somewhat toward the east — which Ptolemy also observed.

When a line is drawn from Capella to the two brighter stars about the horn of Aries [V], the one in the northern knee of Perseus, number 23, inclines a little toward the east, as Ptolemy too observed.

Capella, the preceding foot of Erichthonius [Auriga], and Aldebaran are still in a straight line as nearly as possible — that line passing through the foot of Erichthonius diverging a little toward the east.

So too the star in the more northerly Horn of Tauri stands even now, with respect to the foot of Erichthonius, Capella, and the left shoulder of Orion, just as the stars were arranged in Ptolemy's age, so far as their linear run goes.

I refrain from reviewing more examples, lest I dwell on these too long. Anyone who wants a fuller supply can test it for himself with a thread or a rule, and will find that all those stars which Hipparchus and Ptolemy recorded in their writings as keeping a straight alignment, or very nearly so, hold themselves in exactly the same way in our age too, with nothing in them hidden that any of the senses could detect as a discrepancy. So I cannot wonder enough that there exist some who dare to dispute this, and who, against the very surest experience of long ages, pronounce — far too ignorantly and shamelessly — that the stars do not perpetually preserve the same intervals and positions among themselves.

It must be noted, however, that when an experiment of this kind is set up, all the stars taken into account must be raised so far above the horizon that none of them is subject to the impediment of refraction; or at least, if it should happen otherwise (as occurs in a lower position), one must guard against it and make allowance. For the stars are not all situated above the horizon for us, who dwell under so great an obliquity of the sphere, in the same way as they are in Egypt, where Hipparchus and Ptolemy contemplated these matters.

Since, then, it is sufficiently clear that all the fixed stars are always observed to keep the same position with respect to one another, it will not be difficult, from the given place of Spica Virginis

for the time of the three aforementioned masters, to predetermine the longitudes of the remaining stars that need to be employed; and then, applying the declination they recorded, to derive the latitude of these same stars consonant with that age, and to make plain how far it has changed, through these means, down to the present time — which we shall now do.

Ptolemy reports that Timocharis observed the declination of Spica Virginis to be $1^{\circ} 24'$ north of the equator [a partibus Æquatore Boream p. 1 / 24]. Hipparchus, however, [observed] the same to be at least 36 minutes [of arc] toward the same parts; while he himself noticed that it was inclined half a degree to the south of the equator. Hence, having taken the latitude of Spica Virginis as two degrees everywhere — which they always presupposed (for the utmost precision is not very necessary here, since this star too lies near the autumnal equinox, where the variation of latitude due to the changed obliquity of the ecliptic is scarcely noticed) — and following our reasonings, we earlier worked out, from its given declination and latitude, the longitude of Spica in Virgo. We set forth that this star, at the time of Ptolemy's observation, was in $26^{\circ} 38'$ [part. 26 / 38 m.]. In Hipparchus's case, [it was] earlier by $2\frac{3}{4}^{\circ}$, namely at $23^{\circ} 53'$ [p. 23 / 53 m.]; and in Timocharis's age, two degrees still more removed in antecedence, that is, at $21^{\circ} 53'$ [part. 21 min. 53 m.]. With these established here as our foundation, we shall now proceed to examine the places of the other stars in the manner proposed.

And first we shall make trial through the stars nearer to either of the tropics — which for that very reason are also subject to a greater change of latitude — which is what we intend.

Stella in Capite Borealis II, Apollo sive Castor dicta. [The Star in the Head of the Northern Twin, called Apollo or Castor]

This star, according to our observations, is distant in antecedence from Spica Virginis by Sign 3, degrees 3, minutes 35 [Sig. 3, grad. 3, min. 35]. Its longitude, then, according to the intervals stated above by Timocharis, Hipparchus, and Ptolemy as lying between [them], together with the declinations observed by those same authors, was — as reported by Ptolemy — as is set out here:

	Longitudo: P. / '.	Declinatio: G. / '.	
Timocharis	18 18 II	33 0	Bor.

	Longitudo: P. / '.	Declinatio: G. / '.	
Hipparchus	20 18 II	33 10	(north)
Ptolemy	23 3 II	33 24	

From these we shall, by the method of the following demonstration, examine the [resulting] latitude.

Let FGHI in the next following figure be the Colure of the Solstices [Colurus Solstitiorum]; let FL [represent] the Ecliptic, whose pole is at A; let GLI represent the equator with its own pole at B. Let this northern star of Gemini stand near C, through which let quadrants be drawn

Diagram. A spherical-triangle construction inscribed in a great circle. The circle carries the standard lettering of the worked example, with the principal points arranged around its upper-right quadrant and interior.

- B (upper interior, near top): vertex
- A (top right, near the circumference): vertex
- E (just below B and A, interior): foot of the dropped perpendicular
- C (interior, left of E): vertex
- F (upper left, on the circumference): point on the great circle
- G (left, on the circumference): point on the great circle
- K (interior, lower left): intersection point
- L (interior, lower center): intersection point
- D (lower left interior): vertex
- I (right, on the circumference): point on the great circle
- H (lower right, on the circumference): point on the great circle

are carried from both poles into their respective circles. It is therefore clear that KL is the longitude of the star measured from the vernal intersection [point], while KF is its distance from the summer solstice. The declination DC, moreover, is given for the three separate epochs of these different observers. What we now want to know — namely the star's latitude — we will draw out as follows.

First, for the epoch of Timocharis [Timochares]: since in triangle BAC two sides are given together with angle A. For BA is the distance of those poles for that era, $23^{\circ} 51\frac{1}{2}'$; BC is the complement of the northern declination from Caput II, $57^{\circ} 0'$; and the angle BAC is $11^{\circ} 42'$, since it is measured by the longitudinal distance of the star from the summer tropic. Therefore, dropping the perpendicular BE —

since the angle is not contained between the given sides — the third side CA will be established by means of two component right triangles, in this way.

For in the right triangle BAE, since the angle BAE is known (being the same as the BAC already stated) and side BA is likewise given, the perpendicular BE cannot fail to be $4^{\circ} 42\frac{1}{4}'$; and beyond that, side AE will be left at $25^{\circ} 25'$ nearly. Next, in the other right triangle BEC, from the given sides — BC, the complement of the star's declination, and BE, just now found — and with a right angle at E, the third side CE comes out at $56^{\circ} 52\frac{1}{2}'$. So if we now join the two sides just found, AE and EC, the whole of AC will be $80^{\circ} 17\frac{1}{4}'$, which Caput II measures as the northern distance from the north ecliptic pole. Its complement to the quadrant is the very latitude of the star sought, $9^{\circ} 42\frac{3}{4}'$ north.

Proceeding by the same method for the observation of Hipparchus — where everything is to be understood exactly as already shown — side BC will be $56^{\circ} 50'$; BA, $23^{\circ} 51\frac{1}{2}'$; angle BAE, $9^{\circ} 42'$; BE, $3^{\circ} 54\frac{1}{2}'$; AE, $23^{\circ} 33'$; CE, $56^{\circ} 44\frac{3}{4}'$. From these, therefore, CA is composed at $80^{\circ} 18'$ nearly, the complement of the star's latitude; and accordingly the latitude sought will be $9^{\circ} 42'$.

Finally, by Ptolemy's reckoning, these same quantities will stand as follows: side BC, $56^{\circ} 36'$; BA, $23^{\circ} 51\frac{1}{2}'$ (for Ptolemy fixed the same maximum deviation of the ecliptic from the equator as Timochares and Hipparchus did); and the angle BAE, the difference in longitude from the beginning of Cancer to the present time, is $6^{\circ} 57'$. Side BE accordingly comes out at $2^{\circ} 48\frac{1}{2}'$; AE, $23^{\circ} 42'$; CE, $56^{\circ} 33\frac{2}{3}'$. Hence CA is $80^{\circ} 15\frac{1}{4}'$, from which the star's latitude will be $9^{\circ} 44\frac{3}{4}'$ — which exceeds the latitudes previously found from Timochares and Hipparchus

by one or two scruples, which is imperceptible. Yet by limiting these three latitudes we will do better if a truer value is assumed for that epoch, $9^{\circ} 43'$ (which also does not differ much from the Ptolemaic *Abacus*, where this star's latitude is set at $9\frac{2}{3}^{\circ}$). If this is then compared with the latitude of our own age, $10^{\circ} 2'$, it yields a difference of $19'$ — exactly the amount by which the approach of the ecliptic to the equator at that place requires for the interval of time. For the maximum change of declination from the times of those ancients down to the present is a third part of one degree. Hence what we set out to demonstrate concerning the variation of the latitude of the fixed stars in step with the changed obliquity of the ecliptic has been sufficiently clarified for this northern star of Gemini [the northern star of the Twins].

Now we will test the same thing on the more southerly star of that same constellation, in the following chapter. But so as not to be forced to repeat the

whole procedure at length — a labor more tedious than necessary — we will, by a brief and compact statement of the triangles required for the measurements, reduced to numbers, set out before the reader's eyes the several epochs of the ancients one by one. We will then compare the latitude derived from each with our own determination, so that what we have further proposed may become plainly and briefly known.

Diagram. The same spherical-triangle construction as on the preceding recto, inscribed in a great circle, with the worked example's standard lettering.

- B (upper interior): vertex
- A (top right, near the circumference): vertex
- E (interior, below B and A): foot of the perpendicular
- C (interior, left of E): vertex
- F (upper left, on the circumference): point on the great circle
- G (left, on the circumference): point on the great circle
- K (interior, lower left): intersection point
- L (interior, lower center): intersection point
- D (lower left interior): vertex
- I (right, on the circumference): point on the great circle
- H (lower right, on the circumference): point on the great circle

The Star in the Head of the Southern Twin, called Hercules or Pollux.

This star, by my own observations, is distant in longitude eastward from Spica Virginis [Spica] by Sign 3, $0^{\circ} 33\frac{1}{2}'$ [i.e. 3 signs, $0^{\circ} 33\frac{1}{2}'$].

	Longitudo		Declinat.	
	G.	M.	G.	M
				.
Timochari [Timochares]	21	20 II	30	0 }
Hipparcho [Hipparchus]	23	20 II	30	0 } B.
Ptolemaeo [Ptolemy]	26	5 II	30	1 }
				0

Tempore [For the epoch of —]

		Timocha ris		Hipparc hi		Ptolema ei	
		G.	M.	G.	M.	G.	M.
Latus [Side]	B	23	51	23	51	23	51 $\frac{1}{3}$
	A		$\frac{1}{3}$		$\frac{1}{3}$		
Latus	B	60	0	60	0	59	50
	C						
Angulus [Angle]	B	8	40	6	40	3	55
	A						
	E						
Latus	B	3	29	2	41	1	35
	E		$\frac{2}{3}$		$\frac{1}{2}$		
Latus	A	23	37	23	42	23	48 $\frac{1}{3}$
	E		$\frac{1}{4}$		$\frac{3}{4}$		
Latus	C	59	56	59	57	59	49 $\frac{1}{4}$
	E		$\frac{1}{2}$		$\frac{5}{8}$		
Latus	C	83	33	83	40	83	37 $\frac{2}{3}$
	A		$\frac{2}{3}$		$\frac{1}{2}$		
Latitudo quaesita		6	26	6	19	6	22 $\frac{1}{2}$
[Latitude sought]			$\frac{1}{3}$		$\frac{1}{2}$		B.

We have therefore done well to assume the latitude midway, as it were, between the Hipparchan and Ptolemaic reckonings — 6° 20' — since for our own age the same is found to be 6° 38'. And since on that account it is greater by 18 scruples, just as it is nearest to that place, the obliquity of the ecliptic has been changed, has come closer to the equator, and on that account has enlarged the star's northern latitude by that much. Therefore what we were aiming at is from this sufficiently and evidently clear.

Now we will carry the same demonstration into the open with respect to the other tropic, taking the bright star of the Flying Vulture [Lucida Vulturis volantis — the star Altair, in Aquila].

The Bright Star of the Flying Vulture.

This star is remote in longitude, toward the following signs, by my own observations from Spica Virginis [Spica], by Sign 3, 7° 53' [i.e. 3 signs, 7° 53'].

	Longitudo		Declinatio	
	P.	M.	P.	M
Timochari [Timochares]	29	50 $\times$ ⁷	5	4 } 8
Hipparcho [Hipparchus]	1	50 γ	5	4 } Bor. 8
Ptolemaeo [Ptolemy]	4	35 γ	5	5 } 0

It was therefore at the time of Timocharis and Hipparchus as near as possible to the colure of the winter solstice, nor had it greatly departed from that in Ptolemy's age — so much so that the declination alone (in which these three ancient authorities agree exceptionally well) yields the latitude sought, beyond doubt and with the least possible effort, through the addition of the maximum declination, 29° 40' nearly — so that there is no need of further calculation. But since at our own time the latitude of this star is found to be 29° 21½', and accordingly smaller by 18½ scruples than formerly, it is plain from this infallible testimony too that the star's latitude has been altered through the approach of the ecliptic to the equator.

From this one star alone, then, set near the winter tropic — calling in for counsel only the two preceding stars, which are near the summer solstice — since they exhibit the latitude so precisely (in proportion to the changed obliquity of the ecliptic) and do so in opposite ways, the ecliptic here approaching the star and there receding from it, it has been more than sufficiently demonstrated, which is what we set out to make plain: that the latitudes of the fixed stars are changed according as the ecliptic approaches or recedes from the equator. To confirm this still more fully, the matter does not need it — unless, for the sake of fuller testimony, one should care to test it further in certain stars lying at intermediate places between the tropics and the equinoctials.

Diagram. The same spherical-triangle construction inscribed in a great circle, with the worked example's standard lettering, here drawn for a more southerly configuration (points C, M, L, D clustered low at the left).

- B (top, interior): vertex
- A (top right, near the circumference): vertex
- E (interior, below B and A): foot of the perpendicular

- F (upper left, on the circumference): point on the great circle
- G (left, on the circumference): point on the great circle
- M (interior, lower left): intersection point
- C (lower left interior): vertex
- L (interior, lower center): intersection point
- D (lower left, on the circumference): point
- K (interior, lower center-right): intersection point
- I (right, on the circumference): point on the great circle
- H (lower right, on the circumference): point on the great circle

The Left Shoulder of Orion.

This star is distant in longitude from Spica Virginis [Spica], by my own observations of the motion of the fixed stars, by Sign 4, 2° 53' [i.e. 4 signs, 2° 53'] in the preceding [westward] direction.

	Longitudo		Declin.	
	P.	/	P.	/
Timochari [Timochares]	19	0 ⅈ	1	1 ⅈ } 2
Hipparcho [Hipparchus]	21	0 ⅈ	1	4 ⅈ } B. 8
Ptolemaeo [Ptolemy]	23	45 ⅈ	2	3 ⅈ } 0

Tempore [For the epoch of —]

	Timochar is		Hipparc hi		Ptolema ei	
	G.	M.	G.	M.	G.	M.
Latus [Side]	B 23	51	23	51	23	51
	A	⅓		⅓		⅓
Latus	B 88	48	88	12	87	30
	C					
Angul. [Angle]	B 41	0	39	0	36	15
	A					
	E					
Latus	B 15	23	14	45	13	50

		Timochar is		Hipparc hi		Ptolema ei	
	E		$\frac{1}{2}$				$\frac{1}{2}$
Latus	A	18	27	18	58	19	37
	E						$\frac{1}{2}$
Latus	C	88	45	88	8	87	25
	E		$\frac{1}{3}$				$\frac{1}{2}$
Latus	A	107	12	107	6	107	3
	C		$\frac{1}{3}$				
Latitudo quaesita		17	12	17	6	17	3
[Latitude sought]			$\frac{1}{3}$				M.

From these we have concluded, with greater probability, that the star's latitude in the time of the ancients was 17° 8', since this lies as it were midway between the records of Timocharis and Ptolemy, and is off from Hipparchus by only two scruples at most. For these values are to be limited in the proper way, because in a few scruples their observations were not exact. But since at our own age the latitude of this star is about 16° 53' — reduced by roughly a quarter of one degree — to just the extent that the ecliptic at that place was meanwhile drawing nearer both to the equator and to the star, here too it is evident that what we undertook to show holds rightly.

The Right Shoulder of Orion.

This star is remote in longitude, by my own observations, from Spica Virginis [Spica] eastward by Sign 3, 25° 4' [i.e. 3 signs, 25° 4'].

	Longitudo		Declinatio	
	P.	/	P.	/
Timochari [Timochares]	26	49 ☿	3	5 } 0
Hipparcho [Hipparchus]	28	49 ☿	4	2 } Bor. 0
Ptolemaeo [Ptolemy]	1	34 ♀	5	1 } 5

By adopting the same figure we used for the preceding star, and applying the same method of demonstration, these values result.

For the Time of:

		Timocha ris G.	Timocha ris M.	Hipparch us G.	Hipparch us M.	Ptolem y G.	Ptolem y M.
Side	B A	23	51 $\frac{1}{3}$	23	51 $\frac{1}{3}$	23	51 $\frac{1}{3}$
Side	B C	86	10	85	40	84	45
Angle	B A E	33	11	31	11	28	26
Side	B E	12	47	12	5	11	6
Side	A E	20	18 $\frac{1}{2}$	20	43 $\frac{1}{2}$	21	15
Side	C E	86	4 $\frac{1}{4}$	85	34	84	39
Side	A C	106	22 $\frac{3}{4}$	106	17 $\frac{1}{2}$	105	54
Latitude sought		16	22 $\frac{3}{4}$	16	17 $\frac{1}{2}$	15	54 M.

In this star Ptolemy's recorded value diverges sharply from that of Timocharis and Hipparchus — whatever the source of the error, whether of observation or of the copyists. Since Timocharis and Hipparchus agree very closely on its latitude, with a discrepancy of only 5 minutes arising between them — which in their case was of no great moment — I have judged it safer to take the intermediate latitude, so that it may be the truer and better-bounded value for that time: 16 degrees 20 minutes. And since the present value comes to 16 degrees 6 minutes, it is clear that it is found to have diminished by 14 minutes, just as the proportion of the ecliptic's approach toward both the equator and the star at that place very nearly requires.

Cor Leonis [the Heart of the Lion, Regulus]

This royal star moves eastward through the zodiac, ahead of Spica of Virgo, according to its own proper motion among the fixed stars: 1 sign, 23 degrees, 58 $\frac{1}{2}$ minutes.

	Longitude G.	Longitude M.	Declination G.	Declination M.	
Timochari s	27	54½ ☿	21	20	} B .
Hipparch us	29	54½ ☿	20	40	
Ptolemy	2	59½ ♃	19	50	

Diagram. A spherical-triangle construction within a circle, of the same type used throughout these per-star demonstrations. The labeled points around and within the circle are:

- A (upper left, on the circle): A
- B (top, on the circle): B
- E (interior, near A): E
- C (interior, below B): C
- F (right, on the circle): F
- L (interior, lower middle): L
- I (left, on the circle): I
- G (lower right, on the circle): G
- H (lower left, on the circle): H
- D (lower middle, interior/on a chord): D

For the Time of:

		Timocha ris G.	Timocha ris M.	Hipparch us G.	Hipparch us M.	Ptolem y G.	Ptolem y M.
Side	B A	23	51⅓	23	51⅓	23	51⅓
Side	B C	68	40	69	20	70	10
Angle	B A E	27	54½	29	54½	32	39½
Side	B E	10	53⅓	11	38	12	36
Side	A E	21	21	20	58	20	25

		Timocha ris G.	Timocha ris M.	Hipparch us G.	Hipparch us M.	Ptolem y G.	Ptolem y M.
Side	C E	68	15	68	53	69	39
Side	C A	89	37	89	51	90	4½
Latitude sought		0	23	0	9	0	4½ B.

In this star the latitudes derived from Hipparchus's and Ptolemy's records do indeed recede noticeably from that of Timocharis — yet since Ptolemy himself, who observed this star more carefully than the rest, set its latitude at 10 minutes north, which exceeds Hipparchus's by only a single minute (although his own view regarding the declination departs somewhat), it will therefore be more reliable. If we establish that the latitude of this star in the time of the ancients was one sixth of a degree — which on the present reckoning is at minimum 0 degrees 26 minutes — its latitude is found to have increased by 16 minutes. This is very nearly the same amount by which the ecliptic at that place has likewise drawn the star down toward the equator, so that the star's latitude has in effect grown by almost a quarter of a degree. I am astonished that Copernicus, who approved Ptolemy's latitude in so illustrious a star, did not notice that it lies so close to the ecliptic.

Antares sive Cor ♎ [Antares, or the Heart of the Scorpion]

This star is distant in longitude, measured backward from Spica of Virgo according to its own proper restitution: 1 sign, 15 degrees, 57 minutes.

	Longitude P.	Longitude /.	Declination P.	Declination /.	
Timochari s	7	0 ♎	18	20	} A .
Hipparch us	9	45 ♎	19	0	
Ptolemy	12	25 ♎	20	15	

Diagram. A spherical-triangle construction within a circle. The labeled points are:

- H (upper right, on the circle): H

- I (right, on the circle): I
- G (left, on the circle): G
- D (interior, upper left): D
- K (interior, center-top): K
- L (interior, middle left): L
- F (lower left, on the circle): F
- C (interior, lower middle): C
- E (interior, lower right): E
- B (bottom, on the circle): B
- A (bottom right, on the circle): A

For the Time of:

		Timocha ris G.	Timocha ris M.	Hipparch us G.	Hipparch us M.	Ptolem y G.	Ptolem y M.
Side	B A	23	51½	23	51½	23	51½
Side	B C	71	40	71	0	69	45
Angle	B A E	52	10	50	10	47	25
Side	B E	18	38½	18	7	17	20½
Side	A E	15	9	15	48	16	38
Side	C E	70	37	69	58¾	68	47
Side	A C	85	46	85	45¾	85	25
Latitude sought		4	14	4	14½	4	35 M.

Here the observations of Timocharis and Hipparchus agree almost exactly on this star's latitude, 4 degrees 14 minutes — while Ptolemy deviates too far, since out of his recorded declination he makes it larger by a third of a degree, even though in the Canonical enumeration of the stars he gives it as precisely 4 degrees. Thus

Timocharis's and Hipparchus's record makes it smaller by about a quarter of a degree, so that he is inconsistent with himself, and this designation of his seems the less certain. Standing rather with the two earlier authorities, I have no doubt that the latitude of this star in their age was 4 degrees 14 minutes — since the two agree so beautifully here. And since the same is found in our own time to be 4 degrees 27 minutes, exceeding that ancient value by 13 minutes, this calls for the same ecliptic recession from this star toward the equator around that place, which I labored to prove earlier; and here too it turns out plain enough.

Aldeboram sive Oculus ♂ [Aldebaran, or the Eye of the Bull]

In longitude this star is distant from Spica of Virgo, eastward, according to our own findings: 4 signs, 14 degrees, 4 minutes.

	Longitude P.	Longitude M.	Declination G.	Declination M.	
Timochari s	7	49 ♂	8	45	} B .
Hipparch us	9	49 ♂	9	45	
Ptolemy	12	34 ♂	11	0	

Diagram. A spherical-triangle construction within a circle. The labeled points are:

- G (upper left, on the circle): G
- L (interior, upper left): L
- C (interior, left): C
- F (left, on the circle): F
- D (interior, middle): D
- K (interior, center): K
- H (right, on the circle): H
- I (lower right, on the circle): I
- A (bottom left, interior/on the circle): A
- E (bottom, interior): E
- B (bottom, on the circle): B

For the Time of:

		Timocha ris G.	Timocha ris M.	Hipparch us G.	Hipparch us M.	Ptolem y G.	Ptolem y M.
Side	B A	23	51½	23	51½	23	51½
Side	B C	98	45	99	45	101	0
Angle	B A E	52	11	50	11	47	26
Side	B E	18	37⅔	18	5½	17	19½
Side	A E	15	10½	15	49	16	39½
Side	C E	99	14¼	100	15¾	101	31¾
Side	A C	84	3¾	84	27	84	52¼
Latitude sought		5	56¼	5	33	5	7¾ M.

I cannot wonder enough that these three masters' declinations recorded for this star, when the same longitude is applied, should yield such widely differing latitudes; and although Ptolemy's reckoning comes closer to the numbers entered in his own table, it nonetheless departs furthest of all from the mark. Nor do all the canons present the same latitude for this star, so that I suspect it was corrupted by the carelessness of the copyists. It will therefore be wiser to compare and adjust against each other the latitudes derived from Timocharis and Hipparchus. And since the difference between them is 23 minutes, half of which is 11½ minutes, added to the smaller, Hipparchan, latitude, this will establish the more probable truth, the value closest to that age for Aldebaran's latitude: about 5 degrees 45 minutes. But since at present the same is found to be very nearly 5 degrees 31 minutes, it is evident that here too the ecliptic has approached this star by way of the increased maximum declination, by about as much as that place requires.

That Ptolemy's recorded latitude for this star is grossly erroneous is shown partly by the fact that he sets the change of its declination, from Timocharis down to his own day, at 2¼ degrees — and that around the first third of Taurus, even though

near the equinoxes themselves he gives a somewhat smaller alteration of declination than 2 degrees. It is shown partly from the latitude of the other star in the northern eye of Taurus, which in his own catalogue he sets at precisely 3 degrees; this much is plain enough. For we ourselves find that star's latitude to be 2 degrees 37 minutes, and so the obliquity of the ecliptic at that place requires it to be somewhat narrower — which clearly exceeds Ptolemy's too-large latitude, since the contrary happens in the case of Aldebaran. These two things cannot stand together, and they render Ptolemy's observation thoroughly uncertain. Indeed, the very distance between the two stars in the Eyes of Taurus, which I have repeatedly found by accurate observation to be 3 degrees 10¼ minutes, sufficiently proves that much error lies hidden in Ptolemy's record. For if his longitudes and latitudes are resolved into the distance by means of triangles, [a value comes out at variance —]

they yield an interval of at least 2° 19', falling short of the observed celestial appearance of 51' (which is far too much a discrepancy). For this reason the latitude that Ptolemy assigned to Aldebaran in his own age must necessarily come out smaller, and — since the star could move farther away from the northern pole of the ecliptic — must be reckoned considerably larger. Thus everything, taken together with the observations of our own time, will square more correctly with the proposed line of reasoning.

Moreover, here too, regarding the latitude of Aldebaran — which in our age fills out a southern latitude of at least 5½ degrees — I find it surprising that Copernicus confirmed the lunar parallaxes he had established by means of this very star. For he assumed its latitude, in imitation of Ptolemy, to be a third of one degree smaller than is correct, when in Book 4, Chapter 27 [*De Revolutionibus* IV.27] he sets out to prove this same point from the Moon eclipsing this star — an event which, he reports, was observed at Bologna at the time in question. Yet while he constricts the Moon's latitude by nearly the same amount, so that it agrees as closely as he wished, this was open to doubt. For I myself have found that the Moon's greatest latitude is a quarter of a degree larger than Ptolemy records — as, God willing, I shall one day establish in my *Astronomical Work* [*Opus Astronomicum*] from indubitable observations. Therefore, since both latitudes — that of the Moon as well as that of the star — were larger than Copernicus supposed, they could to some extent coincide, so that the Moon obscured the star in the manner described. But it does not follow from this that his parallaxes were entirely exact, although in these matters no great error of his own lies hidden, as I shall show elsewhere. I pass over the fact that Copernicus

took no account here of the refraction, which is greater for the Moon than for a star — perhaps because this was less well understood by him.

I too have noticed several times that the Moon, by interposing itself, eclipsed this very star; yet I was never able to derive any such latitude — whether in the star or in the Moon itself — from this, the Copernican parallaxes everywhere holding up tolerably well. But on these matters more fully elsewhere.

I shall, however, add two further stars, more carefully noted by the ancients, which stand as if opposed to one another, and that in the regions midway between the solstices and the equinoxes.

The first will be the last, or brighter, of the Pleiades. Timocharis, using the Moon, found it to have a northern latitude of $3^{\circ} 40'$, when it stood in the last degree of Aries [Υ]. Agrinus too (whom others call Agrippa), in Bithynia, likewise determined it by means of the Moon, when this star had already passed the third degree of Taurus [$\mathcal{T}$]. We, however, have consistently observed it placed at $24\frac{3}{4}^{\circ}$ of Taurus [$\mathcal{T}$], holding a northern latitude of $3^{\circ} 55'$. It has therefore increased its distance from the ecliptic by a quarter of a degree — just as that place in Taurus [$\mathcal{T}$], by altering its own declination, has receded from this star and drawn nearer to the equator.

So too the other star, which is the more northerly of the three in the forehead of Scorpius [$\mathcal{M}$], appeared to Timocharis — when it was at 2° of Scorpius [$\mathcal{M}$] — to have a northern latitude of $1^{\circ} 20'$. To Menelaus too, the Roman geometer, when it stood at the end of 6° of Scorpius [$\mathcal{M}$], the same appeared. We, however, finding this star's

Latitude now brought to $23\frac{2}{3}^{\circ}$ of Scorpius [$\mathcal{M}$], find it to be very nearly $1^{\circ} 5'$ northern. Its latitude has therefore likewise diminished by a quarter of a degree — by as much as the ecliptic's approach to the equator requires in that place, and by one further increment as the star itself drew nearer, and as anciently recorded.

This star too Albategnius [al-Battānī], when it had been brought to nearly 18 degrees of Scorpius [$\mathcal{M}$], held to have the same latitude it had once had — just as with the star in the Heart of Leo [Regulus, $\mathcal{Q}$] and with the others he mentions — and he does not hesitate to assert that this same value agrees, even though he reports the inclination of the ecliptic to the equator as much smaller than the ancients did, namely $23^{\circ} 36'$, falling short of their recorded figure by a quarter of a degree. This circumstance could indeed introduce some discrepancy into the latitudes of the stars of his age, once the comparison is made. But to my mind he

is rather too ready to believe his predecessors and to follow the ancients, being in this matter altogether too confidently content, when one might suppose that he had brought to bear some sufficiently accurate observation of his own for scrupulously sifting the latitudes of the stars — from which it is also tolerably clear that he was either not equipped with instruments well suited and finely made for displaying all things, or else that he carried out this consideration somewhat too negligently.

For this reason — since, by the stars already enumerated, it has been confirmed several times by sufficiently evident testimonies that the latitudes of the fixed stars change according to the requirement of the changing obliquity of the ecliptic — one of these two consequences necessarily follows: either the maximum obliquity of the ecliptic was not, in the age of the ancients, as great as they assigned it, or else the latitudes of the stars were genuinely altered in proportion to its nearer approach to the equator. Now the ancients — Timocharis as well as Hipparchus and Ptolemy — cannot credibly have erred by a third of a degree in recording the greatest declination of the ecliptic, especially since all three with one accord, most scrupulously, set down the same value. They could also most easily, and with sufficient precision, establish it by their rules from observation of the Sun at each solstice; nor indeed did the Sun there, at the winter solstice, present any sensible impediment of refraction, standing high enough above the horizon. Necessarily, therefore, the conclusion is drawn that the latitudes of the fixed stars have been changed from the times of the ancients down to the present, and that according to the proportion of the varied obliquity of the ecliptic. This is what, by so many and such undoubted reasonings, we set out from the beginning to demonstrate.

Granted, indeed, that some few stars may be found which protest against this induction — particularly the well-known bright star of Canis Major [Sirius] and certain others — yet I am of the opinion that this has happened rather through the fault of the copyists, who did not correctly reproduce the numbers expressed by Greek letters, than because anything doubtful lurks in those matters we have already established, anything that would deserve a firm contradiction.

I have compared by correspondence, together with the Mathematician of the Most Illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel], the latitudes of the fixed stars in respect of their
altered

altered inclination of the maximum obliquity of the ecliptic, and of the Moon's latitude in its most remote departure from the ecliptic — an excursion still greater than I had found in the ancients, as has appeared to me. He affirmed that he agreed with me on both points, just as these matters are more fully laid open in the *Book of Astronomical Letters* [*Astronomicae Epistolae*].

Therefore, these things having been thus settled and sufficiently set forth, let us proceed to other matters as we have determined — going on, in what follows, to explain the two instruments which we have chiefly used among others in observing the positions of the stars.

On the instruments which were for the most part used in the observations previously recorded.

Since I promised to set before the eyes, and to explain, the instruments employed in the observations already several times mentioned above: here I shall give two, designated principally for that office — namely, so far as concerns the measuring of the distances of stars and their differences of ascension, together with their declinations. One of these I have called the Astronomical Sextant, the other the Equatorial Armillae; of which I shall now treat separately.

On the Astronomical Sextant, an instrument devised by us for searching out the intervals between stars in the heavens, and exceedingly well suited to that purpose.

Since it is by no means granted that the distances of stars can be scrutinized as exactly as need requires by means of the Astronomical Radius — as long experience has taught me, the causes of why this is so to be referred elsewhere — for many years now I have given thought to another instrument by which so necessary a task for astronomy might be faithfully carried out. And indeed from the outset I devised a certain sextant, more readily and reliably suited to this purpose, and had it built — one which shall be delineated and set out at the end of the following book. But since this one, by reason of many requirements, was unwieldy and rather too difficult to handle, as it demanded at least a single observer in its use, I gave thought to others for the same purpose. First I made one forked [bifurcatum], requiring two observers, and furnishing the distances of stars beyond all doubt quite scrupulously, but with somewhat greater trouble, and with no small expenditure of time.

At length, however, I devised yet other sextants, which I call Trigonical [Trigonicos], which with certainty, fineness, and the least labor too supply the remote positions of stars by means of two sights [collimatores] fitted to them. Of these I now have ready to hand sets of three, composed of nearly the same construction and fabric, which the following Figure represents. (To be contin-

Diagram. A large woodcut, occupying the full page, depicting one of Tycho's trigonical sextants mounted on an ornate sculpted pedestal standing on a tiled (checkerboard) floor. The instrument's triangular wooden frame, heavily cross-braced with diagonal trusses, rises from a decorative baluster column; the graduated arc of the sextant (with degree divisions) sweeps along the lower-left edge of the frame. A plumb line hangs from near the apex down to the floor at left. The figure is lettered for cross-reference in the text. Readable labels:

- A (apex, upper right): sighting vane / collimator at the far corner of the frame
- F (upper area, below and left of A): a second sighting vane (the "near" collimator), shown as a small cylindrical sight-pinnule
- C (left side, on the graduated arc): the lower terminus of the graduated arc region
- L, N (upper left, near the end of the arc-arm): labels along the upper sighting arm / arc support
- D (top of the graduated arc): a point along the divided arc
- H (on the arc, near the hub): a point along the divided arc
- E (center, near the hub) [?]
- I (lower center) [?]
- K, K (left and right of the pedestal): the two volutes / shoulders of the pedestal capital
- M (lower left, on the floor): the foot of the plumb line where it meets the tiled floor
- X (center of the pedestal shaft, twice): points on the column [?]

A small circular medallion at the center of the frame's cross-bracing carries an inscription (a maker's or dedicatory cartouche): a three-line lettered name device [Inscription, central medallion (partly legible): "TYCHO / BRA[HE?] /..." — top line plausibly TYCHO, BRA[HE?] below, lower line(s) [?]].

Explanation of the Delineation of the Instrument of the Trigonometric Sextant

[*Explicatio Delineationis Instrumenti Sextantis Trigonici.*]

The whole frame ABC represents the sextant itself, together with its intermediate bracing. Its center, at A, holds a round cylinder fixed into it; the circumference CB, by contrast, is of such extent that it embraces a sixth part of a circle, the sides AC and AB being equal at four cubits each. In addition, a rule AD is fitted to this center, carrying a sight [Pinnacidium] at D, which can be slid back and forth along the circumference, corresponding by parallel slits to the cylinder resting at A. Furthermore, another sight remains fixed at C, likewise furnished with slits on both sides, analogous to the cylinder set at the center. There is also a second cylinder, resting at F, to which a sight at G is assigned, to be applied whenever use demands it — and this for the closer distances of stars, so that the observers do not get in one another's way.

This sextant rests upon a certain support, as appears in the figure, which carries above it a globe that can be turned toward any quarter of the heavens. By its means the instrument can be directed to any plane of two stars at all conveniently from the other side, by the piece E set on below; and it is steadied by the small rods N and O & L M, until one of the observers, through the slits of the sight at rest — the cylinder at A, whose parallels match its size — has sighted some star along both edges; while the other, from the movable sight at D, has in like manner looked along both edges at another star next to the same cylinder. Then, when both at once agree in their observation, the arc CD intercepted between the two sights makes manifest the exact distance of the proposed stars — and this for the larger intervals. For smaller ones the procedure is nearly the same, except that then one observer, fitted at the sight beside G, must look at the cylinder at F, while the other, as before, works the matter around the movable sight D and the cylinder fixed at A in the center. Distances are then to be reckoned, as well, somewhat differently in the circumference of the instrument; for there is the sight G with its companion, which looks toward the cylinder F, parallel to the center A, and is the midpoint of the instrument's arc. Hence the part of the arc that is intercepted from G up to the middle, near the 30th degree, is not counted. For when the movable rule is set exactly at the middle of the arc, and one observer, sighting from the sight D beside cylinder A, while the other from G sights around cylinder F, the same star is seen alike by both. Therefore, by however much the movable sight D is moved from the middle of the arc toward

B, by just so much do the two stars stand apart that hold some small interval between them. The rest the attentive reader will easily gather.

As for the most subtle and exact division of the limb [Lymbus] into transverse points, and likewise the peculiar and especially fitting design of the sights with their slits parallel to the first cylinder — I do not care to disclose these here. I shall treat them one by one in a whole book, in which the mechanical part of astronomy is to be handled, telling there what I have found, by tested experience, to be consonant with the matter, and which I have, as I hope, exercised over a long and not unfruitful use.

And in the second volume of this work, too, these matters will be indicated in their main part, in the very conclusion, in connection with two other instruments described there.

Let this, then, suffice here concerning the instrument of the sextant. The skilled craftsman will more readily understand the rest from inspection of the structure, or rather from its mechanical handling. For that reason I am unwilling to dwell longer on explaining these things.

This much at least I will add: that whenever the Sun, through the instrument, has to be observed with respect to its distance from the Moon or from the star of Venus — as we have very often done (as is plain from the immediately preceding chapter) — then, so that the shadow of the forward cylinder may be more exactly distinguished between the two inner lines of the movable sight as their equal in shadow, a certain channel must be applied to the rule, through which the passing shadow, not being scattered by the brightness of the surrounding air, may all the more apparently fill out the space intercepted between those two lines. This, however, is to be done with the precaution that whoever looks toward cylinder A beside C should have a free prospect, the channel not obstructing him in that place. And if some part of it should be lacking there, it is supplied conveniently enough.

Now, designating the other instrument — namely the organ of the equatorial armillae — I shall presently indicate its use in brief.

On the Equatorial Armillae, which Readily Measure the Declinations and Ascensional Differences of the Stars

[De Armillis Æquatorijis Siderum Declinationes atq Differentias Ascensionales promptè mensurantibus.]

The armillary machines used by the ancients, which carry the zodiac turnable about its own poles outside the meridian, I had for some time held suspect — for reasons partly indicated at the beginning of this chapter, and as long experience itself taught me. I therefore devised other ones, regarding the equator alone, and constructed and made them; and I did this in different ways, fashioning instruments built for this use with a threefold variety of method. Of these I shall set down here the one I already have drawn out, reserving the rest for their proper place, where they will be shown serving the mechanical art.

Diagram. A full-page woodcut of Tycho's equatorial armillary sphere, mounted on an ornamented pedestal and standing on a checkered (tiled) floor. The upper portion is a nest of graduated rings (meridian, equator, declination, and ascensional-difference circles) carrying degree scales numbered around their edges; the lower portion is the cast and scrolled pedestal with caryatid masks, supported on three screw-footed blocks resting on the pavement. The letters are keyed to the explanatory text on the following page. Labels read (positions as they fall on the figure):

- B (top): apex of the outer graduated meridian/limb ring; the scale runs symmetrically down both sides from this point.
- C (upper right): junction on the outer ring near a sight-fitting.
- E (upper left): point on the outer ring opposite C.
- F (upper-left interior): point on the obliquely set ring (the equatorial circle PSR region).
- K (interior, just below F): node on the inner ring at its crossing.
- Q (left interior): a fitting (sight/cylinder mount) on the inner declination ring.
- S (interior, just right of Q): node near the center on the cross-bracing.
- A (center): the central point/axis of the sphere (the cylinder at the instrument's center).
- R (right interior): fitting on the inner ring, symmetric to Q.
- L (right, on a ring): point on a graduated ring toward the right.
- G (right, outer): point on the outer ring; the scale numbers run past it (...45, 50, 55...).
- V (right side): the eagle-/bird-headed bracket fitting projecting from the outer ring on the right.
- X (left side): the matching eagle-/bird-headed bracket fitting projecting on the left.
- I (left interior): node on the inner left ring.

- N (lower-left interior): fitting on the lower inner ring.
- P (left of center): node on the cross-arm near N.
- O (lower interior): fitting/cylinder on the lower inner ring.
- M (lower interior, right of O): point on the lower ring.
- H (lower right): point on the lowest graduated band (the half-circle XTVV semicircle region).
- D (lower left, near the pedestal head): point where the graduated band meets the pedestal mount.
- W (lower right, near the pedestal head): point on the lowest graduated band toward the pedestal mount.
- T (pedestal head): the suspension fitting at the head of the pedestal, between the two caryatid masks, where the plumb-line/zenith bob hangs.
- Y (left, on the lower meridian half-circle): point on the large meridian half-ring forming part of the pedestal cradle.
- Z (central foot): the screw [Cochlea] on the central leveling foot-block.
- AA (three feet): the three screw-footed leveling blocks resting on the pavement (the label AA marks each: upper-left foot, central foot, and lower-right foot).

By more careful inspection of the figure, no doubt, everything can be better discerned and understood than by a long winding of words; nevertheless it is not useless to explain it briefly.

The circle BCDE represents the meridian. Wrought skillfully from solid steel, it measures nearly six feet in diameter. The circle PSR prefigures the equator; fixed at right angles to the other, FGHI, which turns the equator about the axis of the world CD wherever one pleases. Therefore, if one should wish to investigate the ascensional differences of two stars, by moving the sights F and R back and forth, or with either one fixed in a single place, the matter can be carried out by two observers, looking through the parallel slits, on this side and that, around the well-rounded axis DC. For the equatorial arc intercepted by each sight measures the ascensional difference.

The declinations, however, are explored by the other armilla NKLM, revolvable about the same axis — that is, by moving the sights Q or O back and forth on this side and that, and looking toward the cylinder at A beside the center of the instrument.

There must, moreover, be such sights K and L on the other side too, or these same ones applied there, when the declinations of stars are southern, below the

equator. The numbering of the declination is made on this said armilla, upward or downward with respect to the equator, as the matter requires.

Besides these, these armillae rest on the semicircle XTVV with its attached supports, having below the screws [Cochleae] indicated by Z, by which the whole machine is directed to the level, by the aid of a very fine brass thread with a leaden weight BT suspended, into the zenith, according to the elevation of the pole of the proposed place, to a hair's-breadth precision; and it is made conformable to the plane of the celestial meridian, the mechanical meridian of the instrument being EBCD.

The armillae themselves, however, are everywhere of brass within, subject to no warping of themselves. The divisions, furthermore, are all made on this instrument by transverse points, in the manner customary with us, so contrived that they exhibit each single minute distinctly during observation. The rest a diligent inspection, or rather the fabrication itself and the use, will teach.

Nevertheless, in the declinations and ascensional differences just mentioned, and in the others necessary for the restitution of the stars, I have employed not so much these armillae themselves as certain others — held together with one circle and a half, along with an axis facing the poles — which are much larger as well, and exist at least at five cubits, and which therefore furnished more scrupulously and readily what we intended. And this with safe enough convenience, since their structure is underground, on a certain raised hill outside this castle, especially suited to use. I shall describe this, with its own place, and at some time the third armillae as well — these being made out of three circles in the same way, which only excel the ones here depicted in that the equator remains fixed there, with nothing carrying it round, the circle on which it rests (God favoring) being described together with the rest of our astronomical instruments.

On the Proper Motion of the Fixed Stars, as it Corresponds to These Centuries

[De motu proprio Affixarum Stellarum, hisce Seculis correspondente]

Above, in the first chapter, where I dealt fully with verifying the Sun's course for the present age, I likewise examined the annual motion of the fixed stars, taking it as uniform from one or another of them, and comparing them carefully with one another and against the Ptolemaic determinations alongside my own observations. From this I have established that the sidereal year contains 365 days, 6 hours, 9 minutes, 26 seconds, and 43 thirds. [Margin: 6] For this is the

interval of time in which the Sun, by its simple motion, returns each year to whatever fixed star you please. The quantity of the tropical [equinoctial] year is, moreover, the one I set down in the same place: 365 days, 5 hours, 48 minutes, 45 seconds, which falls short of the sidereal year just mentioned by about 20 minutes and 42 seconds. [Margin: 10] For just this much time is required for the Sun, after traversing its whole circle, to overtake again some fixed star that has advanced a little. The star, meanwhile, completes by its own motion exactly 51 seconds [of arc]. This, then, is the small annual advance of the fixed stars in our age. Having investigated this so compendiously, and finding it sufficiently well grounded, I have resolved to set it on record.

But so that this annual motion of the fixed stars may be confirmed by the observations of others, both recent and ancient, I shall undertake to demonstrate it partly from Copernicus [Copernicus] and partly from the records of certain of the ancients.

I take first the earlier observation of Spica Virginis by Copernicus, which he made in the year 1515 — though this seems to be the later one, made about a decade after a more exact reckoning. Computing it according to my own method, by the correction of the place I have used above, I find that Spica then stood at $17^{\circ} 31'$ [recte: $17^{\circ} 3\frac{1}{2}'$?] of Libra ♎ . Since in the year 1585 the same star is found, from my observations, at $18^{\circ} 3'$ of Libra ♎ , it is plain that over the intervening 70 years Spica has advanced, together with the rest of the fixed stars, falling short by only half a scruple [$\frac{1}{2}'$] in the first place. There therefore falls to each year, in proportion, precisely 51 seconds.

Now, so that this same result may be corroborated over a longer span of time, I shall trace the whole matter back, all the way down to us, beginning with Hipparchus [Hipparchus].

He found — as Ptolemy reports, who calls him "Abrachis" [Margin (hand): + in Arabico textu ("+" in the Arabic text)] — in the year 50 of the third Calippic period, which fell in the year 196 from the death of Alexander the Great, that Regulus stood at $29^{\circ} 50'$ of Leo ♌ . Since, then, up to my own observation made in the year 1585 — 1909 years from the death of Alexander — this star stood at $24^{\circ} 24\frac{1}{4}'$ of Leo ♌ , it has in the intervening 1713 years advanced $24\frac{1}{4}^{\circ}$ [recte: see below]. It is certain that, in proportion, there must be reckoned to each year 51 seconds of arc, falling short by at least 13 fourths.

Furthermore, lest anyone suspect that some great irregularity could have crept in over so great an interval of time, I shall adduce an intermediate observation

made on the same star by al-Battānī of Raqqā [Albategnio Aracense; al-Battānī] around the year of our Lord 880, when he found it at $14^{\circ} 5'$ of Leo ♌ — later than Hipparchus's record by 1006 years, and earlier than my own observation by 705 years exactly. In each case, the calculation being made according to the proportion of the years and the motion, by a just distribution, there falls to each year exactly 51 seconds — so exactly that in the earlier interval almost nothing is wanting, while in the later one barely four-thirds fall short. From this it is clear that the motion of the fixed stars was rightly established from Hipparchus through the intermediary al-Battānī: in each year they complete precisely 51 seconds. And it is my intention to conform to the tenor of their progression not only for these most recent centuries but also for the longest stretch of time — it agrees with the span of nearly 1700 years now elapsed. As much as may be gathered from those considerations, drawn meanwhile from Regulus by Hipparchus and al-Battānī, may here be inferred.

Even if these figures do not agree quite so precisely with the determinations of Timocharis [Timocharis] and Ptolemy [Ptolemy] — for the position Timocharis used in the year 454 of Nabonassar, who was 30 years after the departure of [following] Alexander, reporting Spica to have been at $22^{\circ} 4\frac{1}{2}'$ of Virgo ♍ — when compared with my own, allowing for the 1879 years exactly between, yields $25^{\circ} 43'$ [for the advance]. And so to each single year there are owed $49\frac{1}{4}$ seconds, which falls short of the motion I assume by not quite two seconds. (My observation, for the record, was in the year 2333 of Nabonassar.)

From Ptolemy, who places the same star in the year of our Lord 139 at $26^{\circ} 40'$ of Virgo ♍, with 1446 years intervening, there comes $21^{\circ} 21'$ [for the advance]. And so to each year there is owed $53\frac{1}{4}$ seconds, which exceeds my own record by almost as much as was lacking earlier in the case of Timocharis.

Nevertheless, since everything accords so well with my own determinations in the case of Hipparchus and al-Battānī — and since the digressions on either side, arising from the mutually discordant readings of Timocharis and Ptolemy, are themselves equal — there is virtually no clear necessity compelling me to call into doubt the motion I have attributed to the fixed stars. This is especially so since the determinations of al-Battānī, as more recent and undoubtedly made with greater care, deserve more credit in this matter — a point Copernicus himself attests. Hipparchus, moreover, stands as it were midway between Timocharis and Ptolemy, so that from him these results may the more safely be derived.

Indeed, this too counts for me not a little: that the difference of the annual motion — from Timocharis to us, and from Ptolemy down to the present — which

amounts to nearly four seconds at most, when half of it is either added to Timocharis's slower advance or subtracted from Ptolemy's faster one, makes up 51 seconds as closely as possible. Thus the halving of the deduction from either side agrees admirably with my own conclusions. For the observations of the ancients on this matter were not so absolutely exact that they do not stand in need of a fitting limitation and correction — and others before me have not unreasonably suspected as much.

Therefore, presupposing that the annual journey of the fixed stars, in the order of the signs, is exactly 51 seconds, nothing falls within the reach of any of the senses for the next three or four centuries (to say nothing of more) that could deflect us from the goal we seek.

But as for the question of the irregularity in the motion of the non-wandering [fixed] stars — or, as Copernicus puts it, of the *anticipation of the equinoxes* — those theories that he speculated upon so ingeniously and subtly, in order to defend and reconcile the findings of all his predecessors, by no means hold up correctly. This is testified by the 70 years elapsed since his first observation in Spica ♏, in which the reciprocation of the equinoxes (or the advance of the stars) has come out much faster than he supposed it would be in the future. So much so that, whereas at present and henceforth they ought to complete about one degree in roughly a hundred years, he has them finishing it in 70 — and the quantity of the year, likewise, is by no means so slow as he thought, as is clear from what I handed down in the earlier chapter. For these two things in Copernicus scarcely cohere with one another: the motion of the fixed stars is at its slowest precisely when the quantity of the year is at its greatest. But the accurate observations of the present years elude these claims, since they do not correspond to his own periodic restitutions.

According to my own reasoning about the advance, however, the fixed stars complete one degree in 70 years and 7 months. Ptolemy supposed this to happen in 100 years, al-Battānī in 66. My position is intermediate between these, yet comes much closer to al-Battānī's view. Nor does Copernicus's simple motion of the equinoxes differ much from this constitution of mine: it makes the [advance of the] fixed stars in a Julian year amount to $50''\ 12''' \ 5''''$, falling short by at least 48 fourths.

As for the universal motion of the eighth sphere [Sphæræ Octauæ] — corresponding, as they call it, to all the times of the world's age — and how the irregularity in it, as detected by other practitioners, could come about: that I leave to be excused [explained] elsewhere. It is not my present intention to

construct one here; I delegate that labor to a separate work on the restoration of astronomy.

Driven nonetheless here by just causes, I do not hesitate to assert that scarcely so enormous an anomaly underlies the motion of the fixed stars as is detected from the observations of Timocharis and Ptolemy when these are compared with Hipparchus and al-Battānī. For it is not likely that the stars should at one time traverse one degree in 100 years, as Ptolemy reckoned, and at another in 66, as al-Battānī would have it. Rather, in the very observations of those practitioners some flaw undoubtedly lay hidden — which is sufficiently apparent from the fact that the longitudes of those same stars, which they report having observed independently, are not separated from one another in the sky itself in the manner their figures require. So much so that even a deviation of half a degree is found, in these, from the celestial disposition — as will be plain to anyone who compares my own longitude intervals with their records for the same stars.

We see, too, how little of more refined diligence the moderns [Neoterici] have shown in these matters — as is sufficiently clear even from the published observations of Regiomontanus [Regiomontanus] and his own pupil Bernhard Walther [Bernardi Waltheri], and of Werner [Werner].

And yet I would not suppose that the ancients' considerations regarding the fixed stars were so far off the mark that one cannot truly gather from them that some irregularity of motion underlies these stars — although I hold that this arises from some external cause and comes about by accident, and is not deservedly to be imputed to the ancients themselves. As for the question, however, on which I should like to pronounce an absolute verdict, I judge it more prudent to reserve it for the general treatment of astronomy and to hold it back for several years.

It remains, then, for me to add a table, by means of a continuous collection of this annual motion as I have established it, showing at once how much must be added to or subtracted from the longitudes of the stars (predetermined in the canonical enumeration for the year 1600) for any given proposed year — so that, with the slightest effort, the longitude of any star I have catalogued may be available for any year within the next four centuries. The latitude meanwhile alters imperceptibly, since the obliquity of the ecliptic (as I show) gives occasion for this and changes most slowly. And straightaway after this table I shall offer the catalogue [*Abacum*] itself of the restored fixed stars, compiled with no small labor and expense.

In enumerating and naming the stars, I shall use the same appellations that were assigned to them, from parts of certain figures of living creatures or of other things, by a deliberate plan of the most ancient antiquity. For although such images are not really present in the heavens or in the stars, and although this matter savors of a certain heathen and fabulous tradition of the poets (not, however, without veiled wrappings of some shrewd intent), nonetheless I think one ought not rashly to depart from those names that have been received in common use by very many centuries. For the designation of the stars into certain figures is most ancient indeed — as appears even from Job, whether he lived before Moses or after is doubtful. He, at any rate, makes mention of the Pleiades, of Arcturus, and of Orion; and so too the prophet Amos speaks of Arcturus and Orion. Likewise the most ancient of the poets — Hesiod, Orpheus, Homer, and the rest — followed by Euripides, Sophocles, and many more, some of whom flourished somewhat earlier, others a little after the Trojan War (an event accomplished in the age of the Judges, especially of Jephtha, before the enthronement of the kings of the Israelites, as the historians report) — all bear witness to these names here and there in their poems.

Nor is it proper to set aside lightly or to abolish things confirmed by long-standing approbation, unless something better is ready at hand to be restored in their place. And it is to be feared that, by setting aside the ancient names of the stars on the ground that they rest on fictions and fables, license may be given to introduce others anew — to invent here as well, and for each man to shape things at his pleasure. For the true names of the stars, by which the supreme Artificer calls each one (as David testifies in Psalm 146), are utterly unknown to us. Perhaps Adam and the patriarchs knew something of these, or at least had sounder and truer names for them than the ones [now in use]. But now, to the matter at hand.

A Table Showing How Much Must Be Subtracted, in Each of the Two Preceding Centuries, from the Longitude of the Fixed Stars for the Year 1600, Arranged by the Following Canon

This precession table gives the correction (in degrees G., minutes M., seconds S.) to be subtracted from the longitudes of the fixed stars for the year 1600, for collected years (centuries), expanded (individual) years within a century, single years (1–10), and the months.

ANNI COLLECTI (Collected Years)

Anni	G.	M.	S.
1400	2	50	0
1410	2	41	30
1420	2	33	0
1430	2	24	30
1440	2	16	0
1450	2	7	30
1460	1	59	0
1470	1	50	30
1480	1	42	0
1490	1	33	30
1500	1	25	0

ANNI SINGVLI (Single Years 1–10)

An.	G.	M.	S.
1	0	0	51
2	0	1	42
3	0	2	33
4	0	3	24
5	0	4	15
6	0	5	6
7	0	5	57
8	0	6	48
9	0	7	39
10	0	8	30

MENSES (Months — value in S., seconds)

Month	S.	Month	S.
Ian. (Jan.)	4	Iul. (Jul.)	30
Feb.	8	Aug.	34
Mar.	13	Septe. (Sep.)	38

Month	S.	Month	S.
Apr.	17	Octo. (Oct.)	42
Mai. (May)	21	Nou. (Nov.)	47
Iun. (Jun.)	25	Dece. (Dec.)	51

Note beneath the months column: "Subtract the motion of the completed years from the longitude by the following table; and the motion of one month (if you wish), with the seconds removed. // Thus you will obtain what is sought." [*Anni compl. motū aufer à long. seq. Tab: Mensis unā (si uis) sublatis S. // sicq̄ petitem obtinebis.*]

ANNI EXPANSI (Expanded Years 1500–1600)

An ni	G .	M .	S .	Anni	M .	S .	Anni	M .	S .
150 0	1	2	0	1533	5	5	1567	2	3
		5			6	7		8	
150 1	1	2	9	1534	5	6	1568	2	1
		4			6			7	2
150 2	1	2	1	1535	5	1	1569	2	2
		3	8		5	5		6	1
150 3	1	2	2	1536	5	2	1570	2	3
		2	7		4	4		5	0
150 4	1	2	3	1537	5	3	1571	2	3
		1	6		3	3		4	9
150 5	1	2	4	1538	5	4	1572	2	4
		0	5		2	2		3	8
150 6	1	1	5	1539	5	5	1573	2	5
		9	4		1	1		2	7
150 7	1	1	3	1540	5	0	1574	2	6
		9			1			2	
150 8	1	1	1	1541	5	9	1575	2	1
		8	2		0			1	5
150 9	1	1	2	1542	4	1	1576	2	2
		7	1		9	8		0	4
151 0	1	1	3	1543	4	2	1577	1	3
		6	0		8	7		9	3

An ni	G	M	S	Anni	M	S	Anni	M	S
.	.	.			.	.		.	.
151	1	1	3	1544	4	3	1578	1	4
1		5	9		7	6		8	2
151	1	1	4	1545	4	4	1579	1	5
2		4	8		6	5		7	1
151	1	1	5	1546	4	5	1580	1	0
3		3	7		5	4		7	
151	1	1	6	1547	4	3	1581	1	9
4		3			5			6	
151	1	1	1	1548	4	1	1582	1	1
5		2	5		4	2		5	8
151	1	1	2	1549	4	2	1583	1	2
6		1	4		3	1		4	7
151	1	1	3	1550	4	3	1584	1	3
7		0	3		2	0		3	6
151	1	9	4	1551	4	3	1585	1	4
8		2			1	9		2	5
151	1	8	5	1552	4	4	1586	1	5
9		1			0	8		1	4
152	1	8	0	1553	3	5	1587	1	3
0					9	7		1	
152	1	7	9	1554	3	6	1588 [printed 1788]	1	1
1					9			0	2
152	1	6	1	1555	3	1	1589	9	2
2		8			8	5		1	
152	1	5	2	1556	3	2	1590	8	3
3		7			7	4		0	
152	1	4	3	1557	3	3	1591	7	3
4		6			6	3		9	
152	1	3	4	1558	3	4	1592 [printed 1562]	6	4
5		5			5	2		8	
152	1	2	5	1559	3	5	1593	5	5
6		4			4	1		7	
152	1	2	3	1560	3	0	1594	5	6

An ni	G	M	S	Anni	M	S	Anni	M	S
7					4				
152	1	1	1	1561	3	9	1595	4	1
8			2		3				5
152	1	0	2	1562	3	1	1596	3	2
9			1		2	8			4
153	0	5	3	1563 [printed 15 3]	3	2	1597	2	3
0		9	0		1	7			3
153	0	5	3	1564	3	3	1598	1	4
1		8	9		0	6			2
153	0	5	4	1565	2	4	1599	0	5
2		7	8		9	5			1
				1566	2	5	1600	0	0
					8	4			

STELLARVM INERRANTIVM PLVRIMARVM ET PRAECIPVARVM

A Canonical Determination of Very Many of the Most Notable
Fixed Stars, According to the Author's Own Accurate
Observations Recently Drawn Fresh from the Heavens, for
the Completed Year 1600

PRIMO, DE STELLIS QVAE APVD ZODIACHVM CONSPICIVNTVR

(First, Concerning the Stars That Are Seen Near the Zodiac)

ARIES

Column key: **Denominatio stellarum** = the star's description / position in the figure; **Longitudo** = longitude (S. = zodiac sign, G. = degrees, M. = minutes); **Latitudo** = latitude (G. = degrees, M. = minutes, B. = *borealis* / north, A. = *australis* / south); **Magn.** = magnitude.

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
Southern, in the preceding horn (Australis in praecedente cornu)	Υ	27	37	7	8½	B	4:
Northern, and following in the same horn (Borealis ac sequens in eodem cornu)	Υ	28	23	8	29	B	4:
The bright one on the top of the head: the Principal (Lucida in vertice capitis: Principalis)	♂	2	6	9	57	B	3.
In the opening (snout) of the two, the northern (In rictu duarum borea)	♂	2	34	7	23	B	6:
The one more toward the south (Quae magis ad Austrum)	♂	3	20	5	42½	B	6:
The one in the neck (Quae in ceruice)	Υ	27	57	5	24	B	5:
In the loins (In renibus)	♂	8	36	6	7	B	6:
The one at the springing of the tail (Quae in educatione caudae)	♂	12	57	4	8½	B	5
Preceding of the three in the tail (Praecedens trium in cauda)	♂	15	15	1	46½	B	4
Middle (Media)	♂	16	24	2	50	B	5
Last (Vltima)	♂	17	50½	2	36	B	6
In the thigh (In femore)	♂	11	22	1	12	B	6
In the ham of the knee (In poplite)	♂	9	35	1	7	B	6
In the left knee (In genu sinistro) *	♂	9	23	1	30	A	6

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
In the right knee (In genu dextro) *	♄	7	52	0	39	A	6
Small one in the belly (Paruula in aluo) *	♄	8	46	4	1	B	6

ARIES (continued)

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
The one that is within the bright star of the head (Quae est intra lucidam capitis) *	♄	1	41	9	13	B	6
Above the back, preceding the 4 unformed stars (Supra dorsum 4 informium praeced.)	♄	10	35	10	50½	B	5.
Following, namely toward the base of the western [triangle] △, from the following one (Sequens sc. ad basin occi. △ ex sequent.)	♄	11	23	11	16	B	4
Eastern, in the base of the triangle (Orientalis in basi trianguli)	♄	12	40	10	24	B	3.
At the apex of the same triangle toward the north (In apice ejusdem trianguli ab boream)	♄	12	51	12	25½	B	4

TAVRVS

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
In the topmost section (Suprema in sectione)	♄	18	0	5	57	A	5

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
The next after it (Altera post ipsam)	♄	17	30	7	29	A	6:
The third (Tertia)	♄	16	18	8	49½	A	4
The fourth, most southern (Quarta maxime austrina)	♄	15	35½	9	22½	A	4
In the right shoulder (In dextro armo)	♄	21	46	8	41	A	5
In the breast (In pectore)	♄	25	1	8	3	A	4
In the right knee (In genu dextro)	♄	27	59	12	13½	A	4
In the right hock (In suffragine dextra)	♄	24	19	14	30½	A	4
In the left knee (In genu sinistro)	♂	4	9	9	32	A	5
In the left hock (In suffragine sinistra)	♂	3	11	11	48	A	5
In the face of the Hyades, first, in the nostrils (In facie Sucularum prima in naribus)	♂	0	12	5	46½	A	5
Between this one and the northern eye (Inter hanc & oculum boreum)	♂	1	16½	4	2	A	3
The one between the same and the southern eye (Quae inter eandem & oculū australem)	♂	2	22	5	53	A	4
In the southern eye, Aldebaran, the Palilician [star] (In austrino oculo, Aldebaran, Paliliciū)	♂	4	12½	5	31	A	1.
In the northern eye (In boreo oculo)	♂	2	53	2	36½	A	3

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
At the root of the southern horn (Ad radicem cornu australis)	II	8	12	3	40	A	6
In the same horn, more southern of the two (In eodem cornu duarum australior)	II	12	13½	2	30½	A	6
The one more toward the north (Quae magis in boream)	II	11	4	1	49½	A	4
At the extremity of the same (In extremitate ejusdem)	II	19	12	2	14	A	3
At the origin of the northern horn (In origine cornu septentrionalis)	II	6	35	0	40	B	5
At the extremity, shared with the right foot [of Auriga] (In extremitate, cōmunis cum dext. pe-)	II	16	59½	5	20	B	2
In the ear of the two, the northern. (Concerning Auriga / "de Heniochi") (In aure duarum borea. (de Heniochi)	II	2	54	1	4	B	5

TAVRVS (continued)

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
More southern (Australior)	II	2	38	0	35	B	4
In the neck of the two, preceding (In collo duarum praecedens)	♄	27	51	1	12	B	5

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
The one that follows (Quae sequitur)	II	0	28½	0	45½	A	6
In the neck of the quadrilateral, of the preceding stars, the northern (In ceruice quadrilateri praecedentiū au-)	II	0	4	5	16	B	6
Of the same side, the northern (the southern) (Eiusdem lateris borea strina)	♄	29	45½	7	55	B	5
Of the following side, the southern (Sequentis lateris australi)	II	2	34	3	57	B	5
Of this side, the northern (Huius lateris borea)	II	2	25½	5	45½	B	5
Western of the three brighter ones in the Pleiades (Occidentalis lucidiorū triū in pleiadib⁹)	♄	23	50	4	11	B	5
The lowest, and nearest to the western one (Infima & occidentali proxima)	♄	24	3	4	2	B	6
Middle, and the bright one of the Pleiades (Media & lucida pleiadum)	♄	24	24	4	0	B	3
The one that is at the cusp [of the Pleiades] toward the east (Quae est in cuspidē ad Ortum)	♄	24	47	3	55	B	5
In the hoof of the left	II	19	57	13	30	A	6

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
foot (In vngula pedis sinistri) *							
Little star in the heel of the following foot (Stellula in talo pedis sequentis) *	II	0	10	12	2	A	6
The one in the right shoulder (Quae in armo dextro) *	II	1	58½	8	41	A	5
Preceding of the three below the Hyades (Praecedens trium infra Sucas) *	II	1	42	6	56½	A	5
Middle of the same (Media earundem) *	II	3	28	7	4½	A	5
Following (Sequens) *	II	4	55	6	17½	A	5
Small one in the southern horn (Paruula in australi cornu)	II	15	2½	1	4	A	6
Following one in the same horn (Sequens in eodem cornu)	II	16	55½	1	20	A	6
Small one following the four in the section (Paruula sequens quatuor in sectione) *	♄	17	33	9	34½	A	6
The one that is between the two preceding, in the quadrilateral [□] of the neck (Quae est inter binas praeced. in □ colli)	♄	29	22½	6	33	A	5
*							

GEMINI

Denominatio stellarum	Long. S.	Long. G.	Long. M.	Lat. G.	Lat. M.	B./ A.	Ma gn.
In the upper head. Castor, Apollo (In superiori capite. Castor, Apollo)	♊	14	41	10	2	B	2
In the lower head. Pollux, Hercules (In inferiore capite. Pollux, Hercules)	♊	17	43	6	38	B	2
In the left hand of the preceding twin (In sinistra manu praecedentis gemini)	♊	5	32	10	58	B	5
In the left arm (In sinistro brachio)	♊	9	54	7	43	B	4
In the shoulder-blades of the same (In scapulis eiusdem)	♊	13	24	5	42½	B	4
In the right shoulder (In dextro humero)	♊	15	47	5	10	B	5

Book I, CAPVT SECVNDVM — Star catalogue (epoch 1600), continued.

The column headings printed at the top of each table page are: **Denominatio stellarum** (description of the stars) | **Longitudo** (S. = zodiac sign, G. = degrees, M. = minutes) | **Latitudo** (G. = degrees, M. = minutes, B./M. = north/south of the ecliptic — *Borealis/Meridionalis*, printed here as B/A) | **Magn.** (magnitude). The latitude direction column is printed with the letters **B** (= *Borealis*, north) and **A** (= *Australis / Meridionalis*, south); both are reproduced verbatim. An asterisk (*) in the description column is the source's own mark, reproduced as printed.

GEMINI (continued)

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
In the left shoulder of the following Twin (<i>In sinistro</i>	♊	1	6 8	3	3	B	4

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
<i>humero sequentis gemini</i>)							
On the right side of the leading Twin (<i>In latere dextro antecessoris</i> II)	☿	1 3	18	2	56	B	6
Little star in the left elbow of the upper Twin (<i>Stellula in sinistro cubito superioris</i> II)	☿	1 4	10	6	0½	B	6
In the northern and topmost knee (<i>In boreali & supremo genu</i>)	☿	4	22	2	11	B	3
In the left knee of the following Twin (<i>In sinistro genu sequentis</i>)	☿	9	26	2	6½	A	3
The star in the belly of the southern Twin (<i>Quae in ventre meridionalis gemini</i>)	☿	1 2	56	0	13½	A	3
In the ham of the lower Twin (<i>In poplite inferioris gemini</i>)	☿	1 3	13	5	41	A	3
In the foot of the leading Twin, leading (<i>In pede praecedentis gemini antecessoris</i>)	II	2 7	53	0	58	A	4
The following one in the same foot, called the Heel (<i>Sequens in eodem pede, dicta Calx</i>)	II	2 9	44	0	53	A	3
At the tip of the right foot, leading (<i>In extremitate pedis dextri, praeced. II</i>)	☿	1	14	3	8	A	4
The bright star of the foot (<i>Lucida pedis</i>)	☿	3	31	6	48½	A	2
In the lowest part of the foot of the following Twin (<i>In infimo pede sequentis</i> II)	☿	5	29½	10	9	A	4
In the heel of the same foot (<i>In calce pedis ejusdem</i>) *	☿	7	56	9	41	A	6
The star above the knee of the lower Twin (<i>Quae est supra genu</i>	☿	6	23½	1	12	A	6

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
<i>inferioris gemini</i>)							
In the thigh of the upper Twin (<i>In femore superioris gemini</i>) *	☿	8	37½	1	31	B	6
The one below the head of the lower Twin, in the hand (<i>Quae infra caput inferioris in manu</i>) *	☿	1 9	42	5	44	B	6
A small star between the two heads (<i>Paruula inter utrumque caput</i>) *	☿	1 7	4½	7	14	B	5
At the ear of the upper Twin (<i>Ad aurem superioris gemini</i>) *	☿	1 3	29	9	42	B	5
Leading, near the topmost foot: closer to the Greek figure (<i>Praeced. ad summum pedem: Propus graece</i>)	♄	2 5	22	0	13	A	4

CANCER

Description of the star	Sig n	°	'	Lat °	Lat '	N /S	Ma g.
The nebulous star in the breast, which is called the Manger (<i>Nebulosa in pectore quae praesepe vocatur</i>)	♁	1	46 ½	1	14	B	ne b.
The northern one of those leading, in the square of Cancer (<i>Borea praecedentium in ☐ cancri</i>)	☿	2 9	49	1	31½	B	5
The more southern one (<i>Australior</i>)	♁	0	9½	0	47½	A	5
The northern Ass (<i>Asellus boreus</i>)	♁	1	57	[numeral: ?]	8	B	4
The southern Ass (<i>Asellus australis</i>)	♁	3	8	0	4	A	4
In the burning arm (<i>In brachio</i>)	♁	8	3½	5	8	A	3

Description of the star	Sig n	°	'	Lat °	Lat '	N /S	Ma g.
<i>austrino</i>)							
In the northern arm (<i>In brachio boreali</i>)	♂	0	44	10	23	B	5
At the tip of the northern foot (<i>In extremitate pedis borei</i>)	♂	2	56	1	15½	B	5
		3					

CANCER (continued)

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
At the tip of the southern foot (<i>In extremo pedis austrini</i>)	♂	2	4	7	5	A	5
		5					
The brighter star at the root of the tail (<i>Quae in radice caudae lucidior</i>) *	♂	2	45½	2	18½	A	4
		5					
The next following one, on the back (<i>Proxime sequens in dorso</i>) *	♂	2	12½	1	4	A	6
		8					
The northern of the three in the southern arm (<i>Borealis trium in brachio australi</i>)	♂	6	47½	1	54	A	6
The southern one in the same (<i>Australis in eodem</i>)	♂	1	36	5	36	A	5
		0					
The northern of the two in the muzzle (<i>Duarum in rostro, septentrionalis</i>)	♂	5	27	7	14	B	6
The lower and southern one (<i>Inferior & australis</i>)	♂	7	36½	5	20	B	6

LEO

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
In the nostrils (<i>In naribus</i>)	♂	9	41½	10	23	B	4
In the open mouth (<i>In hiatu</i>)	♂	1	16½	7	52	B	4
		2					

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
The more northern of the two in the head (<i>In capite duarum borealior</i>)	♌	1 5	51	12	21	B	4
The more southern one (<i>Australior</i>)	♌	1 5	5	9	40	B	3
The northern of the three in the neck (<i>In collo trium borea</i>)	♌	2 1	57½	11	50	B	3
The middle and bright star of the neck (<i>Media & lucida colli</i>)	♌	2 3	59	8	47	B	2
The southern one (<i>Australis</i>)	♌	2 2	20	4	52	B	3
Heart, Regulus, the Little King (<i>Cor, Regulus, Basiliscus</i>)	♌	2 4	17	0	26½	B	1
The more southern one in the breast (<i>In pectore australior</i>)	♌	2 4	50½	1	25¾	A	5
The next-closest one leading Regulus (<i>Antecedens Regulum proxime</i>)	♌	2 1	4½	0	0½	B	4
The one that leads it, in the right knee (<i>Quae hanc praecedit in genu dextro</i>)	♌	1 7	54½	0	16	B	5
In the right side of the Dragon [recte: Ursa?] (<i>In Drace dextra</i>)	♌	1 6	7	3	10	A	4
The following one in the other foot (<i>Sequens in altero pede</i>)	♌	1 8	40	3	47	A	4
In the left side of the Dragon (<i>In Drace sinistra</i>)	♌	2 3	46	3	55	A	4
In the left armpit (<i>In sinistra axilla</i>)	♍	0	48	0	8	B	4
The leading of the three in the belly (<i>In ventre trium antecedens</i>)	♌	2 2	24	2	10	B	6
The more northern of those following (<i>Sequentium borealior</i>)	♍	2	6	5	56	B	6
The more southern one	♍	4	5	2	49½	B	6

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
<i>(Australior)</i>							
The leading of the two in the loins <i>(Praecedens duarum in lumbis)</i>	♏	3	14	12	53	B	5
The one that follows, bright <i>(Quae sequitur, lucida)</i>	♏	5	41	14	20	B	2
The leading and northern of the two in the haunch <i>(In clune duarum praecedens & borea)</i>	♏	7	50	9	41½	B	3

LEO (continued)

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
The following and southern one <i>(Sequens & austrina)</i>	♏	9	8	7	50½	B	6
In the thigh <i>(In femore)</i>	♏	1 1	58½	6	7	B	3
In the hinder knee <i>(In genu posteriori)</i>	♏	1 3	8½	1	40	B	4
In the middle of the foot <i>(Media in pede)</i>	♏	1 5	57	0	33	A	4
At the bottom of the foot <i>(Infima in pede)</i>	♏	1 9	27	3	2½	A	4
The bright star at the tip of the tail <i>(In extremo caudae lucida)</i>	♏	1 6	3	12	18	B	1
The outermost in the hoof of the left foot <i>(Extrema in ungula pedis sinistri) *</i>	♏	1 6	32	4	48	A	6
In the hoof of the other, leading foot <i>(In ungula alterius pedis praecedentis) *</i>	♏	1 6	1½	5	43	A	5
The one nearly in the middle of the body <i>(Quae in medio corpore fere) *</i>	♏	0	14	10	17	B	6

VIRGO

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
The northern of those leading, in the square of the head (<i>Borealis praecedentium in □ capitis</i>)	♍	1 7	44	0	6½	B	5
The southern one (<i>Australis</i>)	♍	1 8	33	4	37	B	5
The northern of the two following, in the face (<i>Sequentium duarum in vultu borea</i>)	♍	2 2	7	8	3½	B	5
The southern one (<i>Australis</i>)	♍	2 1	58	6	10	B	5
At the tip of the southern and left wing (<i>In extremo alae austrinae & sinistrae</i>)	♍	2 1	32	0	43	B	3
The leading of the four in the left wing (<i>Praecedens quatuor in sinistra ala</i>)	♍	2 9	16	1	25	B	4
The other following one (<i>Altera sequens</i>)	♍	4	35½	2	50	B	3
The small one before the last (<i>Penultima parua</i>)	♍	9	28½	2	23½	B	6
The last one (<i>Ultima</i>)	♍	1 2	37	1	45	B	4
On the right side, under the girdle (<i>In dextro latere sub cingulo</i>)	♍	5	55	8	41	B	3
On the right and north of the wing, leading the three (<i>In dextra & borea alae trium praecedens</i>)	♍	2 9	53	13	36½	B	5
The southern of the two remaining (<i>Reliquarum duarum austrina</i>)	♍	1	52	11	37	B	6
The more northern one, called the Vintager (<i>Borealior, Vindemiatrix</i>)	♍	4	23½	16	15½	B	3

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
<i>vocata</i>)							
In the left hand, Spica (<i>In sinistra manu, Spica ♏</i>)	♌	1	16 8	1	59	A	1
Under the apron, in the right haunch (<i>Sub perizomate in clune dextra</i>)	♌	1	22½ 5	8	10	B	3
In the left hip, the most northern (<i>In sinistra coxa borealissima</i>)	♌	1	58½ 7	3	11	B	6
The more northern of the two following (<i>Sequentium duarum borealior</i>)	♌	2	9½ 1	1	45½	B	3
The more southern one (<i>Australior</i>)	♌	1	44 9	0	19½	A	6
In the left knee (<i>In genu sinistro</i>)	♏	2	44 4	2	24½	B	6

VIRGO (continued)

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
The more northern of the two in the upper hem (<i>Borealis in superiori fimbria duarum</i>)	♍	2	49 7	11	2½	B	5
The middle of the three in the hem (<i>Media trium in fimbria</i>)	♍	2	9 8	7	18½	B	4
The lowest and southern one (<i>Infima & australis</i>)	♍	2	51 8	2	57½	B	4
The more southern of the two in the upper hem (<i>Australior duarum in superiori fimbria</i>) *	♍	2	51½ 9	11	48	B	4
In the southern foot (<i>In australi pede</i>)	♏	1	22	0	31½	B	4
In the northern or right foot (<i>In boreali seu dextro pede</i>)	♏	4	30	9	49	B	4
The lower of the two, between the	♍	1	21	10	26	B	6

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Ma g.
Vintager and the girdle (<i>Inferior duarum inter vindem. & cing.</i>)							
The one following that which is in the right haunch (<i>Sequens illam quae in clune dextra</i>) *	♌	2	37½	9	40½	B	6
The one that is in the neck (<i>Quae est in ceruice</i>) *	♌	2	45½	4	59½	B	6
The small one following the Vintager (<i>Paruula sequens vindemiaticem</i>)	♌	8	25	16	14	B	6
Leading the three, in a straight line on the northern wing (<i>Praecedens trium in recta linea alae boreae</i>) *	♌	1	11	12	40½	B	5
The middle of the same (<i>Media earundem</i>) *	♌	1	46	12	34½	B	6
The following one (<i>Sequens</i>) *	♌	2	11	13	7½	B	5
The one that is between the fourth and the fifth (<i>Quae est inter quartam & quintam</i>) *	♌	2	56½	3	22½	B	6

LIBRA

Description of the star	Sig n	°	'	Lat °	Lat '	N /S	Ma g.
The southern pan (<i>Lanx austrina</i>)	♌	9	31	[numeral: ?]	26	B	2
The one above the southern pan (<i>Quae est supra australem lancem</i>)	♌	8	42	1	55	B	5
The northern pan (<i>Lanx borea</i>)	♌	1	48	8	35	B	2
The one above the northern pan, toward the west (<i>Quae</i>	♌	9	40	8	18½	B	4

Description of the star	Sig n	°	'	Lat °	Lat '	N /S	Ma g.
<i>supra borealem lancem ad occasum</i>)							
The first from the southern pan, toward the east (<i>Prima ab austrina lance ad ortum</i>)	ℓ	1	26 2 ½	1	14	B	5
The second from the same pan, toward the east (<i>Secunda ab eadem lance ad ortum</i>)	ℓ	1	19 6	2	58½	B	6
The third from the same pan, toward the east (<i>Tertia ab eadem lance ad ortum</i>)	ℓ	1	33 9	4	28	B	3
The one below this, toward the east (<i>Quae est infra hanc ad ortum</i>)	ℓ	2	48 1 ½	4	4	B	4
The one below the same, toward the west (<i>Quae infra eandem ad occasum</i>)	ℓ	1	27 9	2	21	B	4
The one below the northern pan, toward the east (<i>Quae est infra boream lancem ad ortum</i>)	ℓ	1	46 5	8	7	B	4

SCORPIUS

Description of the star	Sig n	°	'	Lat °	Lat '	N/ S	Mag .
The topmost in the forehead (<i>Suprema in fronte</i>)	ℓ	2	36 7	1	5	B	2
The middle one in the forehead (<i>Media in fronte</i>)	ℓ	2	59 6	1	54½	A	3

[The Scorpius table continues beyond this page.]

Book I, Chapter II — Star Catalogue (epoch 1600), continued

The per-constellation catalogue continues. Column headers across all four pages: **Denominatio Stellarum** (Description of the stars) | **Longitudo** (S. = sign, G. = degrees, M. = minutes) | **Latitudo** (G. = degrees, M. = minutes, then B. = Borealis/northern or A. = Australis/southern) | **Magn.** (magnitude). The zodiac-sign glyph in the "S." column is rendered here by the constellation name; "ne." in the magnitude column = *nebulosa* (nebulous). Within each table the description is given in the modern English of the Latin; the Latin description is preserved verbatim where the abbreviations matter.

Scorpius (continued)

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
Southernmost of the three on the forehead, of the bright ones (Australis trium in fronte lucidiorum)	♏	27	25	5	22½	A	3:
The one still further south, in the foot (Quae adhuc magis ad austrum est, in pede)	♏	27	43½	8	27½	A	4.
Northernmost of the forehead (Borealissima frontis)	♏	29	3½	1	42	B	4.
Small one in the bright ones of the forehead [in the Δ], and the fifth (Parvula in Δ cum lucida frontis & quinta)	♏	28	7	0	14	B	5.
Preceding the heart, to the north (Praecedens cor, ad boream)	♏	2	11	3	55	A	4
Glowing in the middle, Antares, or the so-	♏	4	13	4	27	A	1.

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
called Heart (In medio rutilans, Antares seu Cor dicta)							
The one that follows the heart, to the south (Quae cor sequitur ad austrum)	♄	5	51½	5	50	A	4
In the preceding lower feet (In praecedentibus inferioribus pedibus)	♄	0	46½	6	37½	A	5.

SAGITTARIUS

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
In the northern part of the bow, the more southern of two (In boreali parte arcus duarum australior)	♄	0	47½	2	0	A	4
The more northern in the same part of the bow (Boreali in eadem parte arcus)	♄	27	41½	2	27½	B	4.
In the left shoulder (In sinistro humero)	♊	6	51	3	31	A	4
Preceding this one, in the arrow (Antecedens hanc in jaculo)	♊	4	40	3	50	A	5.
Preceding of three in the head (Trium in capite praecedens)	♊	7	56½	1	44½	B	4
The middle one (Media)	♊	9	28	0	59	B	4.
The last one (Ultima)	♊	10	43	1	31	B	4
First at the junction	♊	12	44	3	6½	B	6.

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
(Prima in contactu)							
In the northern junction, the middle one (In boreo contactu, media)	♊	13	54½	4	17	B	4
Following and higher (joined) (Sequens & superior — iuncta)	♊	14	11	6	9½	B	5
The one east of these, forming a Δ with the two dim ones below (Hac orient. duab. obscuris forma Δ sub-)	♊	19	8½	5	8	B	6
Eastern and last, in the upper junction (Orientalis & ultima in superiori contactu)	♊	22	52½	5	12	B	6
Dim one in the lower junction toward the east (Obscura in inferiori contactu ad ortum)	♊	19	24	1	25	B	6.
Dim one in the right elbow (Obscura in dextro cubito)	♊	16	26	3	8	A	6.

CAPRICORNUS

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
Northern of three in the preceding horn (Borealis trium in cornu praecedente)	♊	28	18	7	2½	B	3
The middle one (Media)	♊	28	51	6	53	B	5

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
The southern one (Australis)	♊	28	31	4	41	B	3
Nebulous, higher up in the preceding horn (Nebulosa superius cornu praecedens)	♊	27	8	7	16	B	6.
Nebulous, western, the base of the Δ on the front (Nebulosa occident. basis Δ in fronte)	♊	28	57	0	48½	B	ne.
Nebulous, eastern (Nebulosa orientalis)	♊	29	41	0	28	B	ne.
Highest in the same triangle (Suprema in eodem triangulo)	♊	29	37	1	20	B	6
Nebulous, preceding, on the front (Nebulosa praecedens in fronte)	♊	27	13	0	24	B	ne.
In the neck, the northern of two (In cervice duarum borea)	♊	2	49	3	25	B	6
Southern (Australis)	♊	2	6	0	15	B	6
Dim one, preceding, in the right knee (Praecedens in dextro genu obscura)	♊	1	47	6	58	A	6.
Following, in the left knee (Sequens in sinistro genu)	♊	2	28	9	2	A	6.
In the left shoulder- joint (In sinistro armo)	♊	6	13	8	8	A	6
Lowest, in the belly (Infima in ventre)	♊	11	24½	6	56	A	5

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
Following, northern of two adjacent ones, below the belly (Sequens borea duarum contig. sub aluo)	⌘	12	0	6	29	A	6
The more eastern of three in the middle of the belly (Trium in medio ventre orientalior)	⌘	9	23	4	25	A	6.
The lowest of them (Infima earum)	⌘	7	31	4	27	A	6
Northernmost of three (Septentrionalis trium)	⌘	7	18	3	1	A	5
The more forward of two on the back (Duarum in dorso anterior)	⌘	8	21	0	29	A	5:
Following these, on the back (Sequens earundem in dorso)	⌘	12	7	1	16½	A	5:
Preceding, of the two at the flanks (Antecedens duarum ad ilia)	⌘	14	25	4	48	A	4.
Following these (Sequens earundem)	⌘	16	6	4	49	A	5:
Preceding of the two bright ones in the tail (Duarum lucidarum in cauda praecedens)	⌘	16	14	2	26	A	3:
Following (Sequens)	⌘	18	0	2	29	A	3:
Preceding, in the upper tail (Antecedens in	⌘	18	14	2	22	B	5:

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
cauda superiori)							
Of the rest, southern, in the upper tail (Reliquarum in superiori cauda australis)	♊	20	27	0	14½	A	5
Preceding this one, to the north (Praecedens hanc ad septentrionem)	♊	20	16	0	10	A	6.
Northern, at the very end of the tail (Borea in extremo caudae)	♊	19	54	4	17	B	6.

AQUARIUS

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
On the head (In capite)	♊	22	6½	15	23	B	6:
In the right shoulder, the brighter (In humero dextro, clarior)	♊	27	19½	10	42	B	3:
Dimmer and more southern (Obscurior & australior)	♊	26	36	9	11½	B	5
In the left shoulder (In humero sinistro)	♊	17	51	8	42	B	3
The one on the back below the armpit (Quae in dorso sub axilla)	♊	18	38	6	0½	B	5
Following and lower, of three in the left hand (Sequens & inferior trium in sinistra manu)	♊	10	51	4	50	B	5
The middle one (Media)	♊	7	28½	8	19	B	5
Preceding, the brighter	♊	6	12	8	10	B	4

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
(Antecedens lucidior)							
In the right elbow (In cubito dextro)	✕	1	10	8	17½	B	3
In the right hand, the more northern (In dextra manu borealior)	✕	3	4½	10	31	B	5:
Preceding of the two remaining southern ones (Reliquarum duarum australium praecedens)	✕	3	23	8	52½	B	4
Following (Sequens)	✕	4	53	8	10	B	4
Preceding of two in the right cotyla [hip-socket] (In cotyla dextra duarum praecedens)	≍	27	45	2	46	B	4.
Following of them (Sequens earum)	≍	28	31	2	29½	B	6
In the right thigh (In dextro femore)	≍	29	53	1	10	A	5
The one at the buttocks (Quae est ad clunes)	≍	23	13	2	0	A	4.
Southern in the right shin, Scheat (Australis in dextra tibia, Scheat)	✕	3	22	8	10	A	3
Northern, or the one at the knee (Borea, seu quae ad genu est)	✕	3	5	5	37	A	5
In the left hip (In sinistra coxa)	≍	29	40	5	40	A	6
In the left knee, the more southern of two (In sinistro genu duarum australior)	≍	26	55½	10	48½	A	5.

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
The more northern (Borealiior)	≈	29	50	9	57½	A	6:
In the outpouring of water, the first from the hand (In effusione aquae à manu prima)	✕	3	52	4	8½	B	4.
The southern one that follows (Succedens australis)	✕	6	4	0	19½	A	4
Following, in the first bend of the water (Sequens in primo flexu aquae)	✕	9	0	1	24	A	6
The one that accompanies it (Quae eam comitatur)	✕	11	38	1	0	A	5
In the other, southern, bend (In altero flexu australi)	✕	11	33	2	49	A	5.
Preceding and more northern, of the two that follow (Praecedens & borealiior duarum sequent.)	✕	10	43	3	58½	A	5
Following and more southern (Sequens & australior)	✕	11	11	4	10½	A	5
Near this one, inclining southward (Prope hanc, in austrum declinans)	✕	11	14½	4	44	A	5
Preceding, of two adjacent ones after this (Post hanc duarum contiguarum praecedens)	✕	14	7	10	59	A	5

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
Following of those same adjacent ones (Sequens earundem contiguarum)	✕	14	38	11	33	A	5
In the third bend of the water, the northern of three (In tertio aquae flexu borea trium)	✕	13	3	14	29	A	5
Middle of the three in the third bend of the water (Media in tertio aquae flexu)	✕	13	46	15	16½	A	6
Following, and southern, of three (Sequens trium & australis)	✕	14	44	16	23	A	6.
Northern of three following ones (Sequentium trium borealis)	✕	7	54½	14	45	A	5
The middle of those same three (Media trium earundem)	✕	8	21	15	30	A	5
Southern of these three (Australis harum trium)	✕	9	50	16	31	A	5.
In the last bend, the upper of three (In ultimo flexu trium superior)	✕	4	25	14	25½	A	5
The middle one (Media)	✕	4	2	15	40	A	5
The lowest, next to Fomalhaut (Infima, proxima Fomahant)	✕	3	17	15	53	A	5
Last in the outpouring,	≈	28	11½	21	0	A	1

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
Fomalhaut (Ultima in effusione, Fomahant)							

PISCES

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
In the mouth of the southern fish (In ore piscis austrini)	✕	13	2	9	4	B	5:
Southern of two on the back of the head (Duarum in occipite australis)	✕	15	50½	7	17½	B	4
Northern, on the back of the head (Borea in occipite)	✕	17	50½	8	54½	B	6
Preceding of two on the back (Praecedens duarum in dorso)	✕	19	42	9	3	B	5
Following, on the back (Sequens in dorso)	✕	21	56½	7	13½	B	5
Preceding, on the belly (Praecedens in aluo)	✕	17	21	4	27	B	5.
Following, on the belly (Sequens in aluo)	✕	21	5	3	25	B	5
In the tail (In cauda)	✕	27	2	6	23½	B	5:
Above this one, toward the east (Supra hanc ad ortum)	✕	28	27	7	27	B	6
Following (Sequens)	Υ	2	29	5	28	B	6:
Preceding of three brighter ones in the southern cord (In lino austr. lucidiorum trium)	Υ	8	36	2	11	B	4

Description	Long. sign	Long. °	Long. '	Lat. °	Lat. '	B./ A.	Ma gn.
praecedens)							
The middle of those (Earundem media)	Υ	11	58	1	5½	B	4
Following (and northern) (Sequens — dens & borea)	Υ	14	19	0	57½	B	4
Preceding, of two small ones in the bend of the cord (In flexu lini duarum exiguarum antece-)	Υ	12	25	1	31	A	6
Following these, toward the south (Earundem sequens ad austrum)	Υ	13	46	4	19½	A	6
Preceding of three after the bend (Post flexionem trium praecedens)	Υ	17	33	3	3	A	5
The middle one (Media)	Υ	19	56	4	40½	A	5:
Following, and last (Sequens & ultima)	Υ	21	57½	7	56	A	5:

Star catalogue (epoch 1600) — continued

Pisces [Pisces] (conclusion)

Column headers: Denomination of the stars | Longitude (S. = sign, G. = degrees, M. = minutes) | Latitude (G. = degrees, M. = minutes; B. = north, A. = south) | Magnitude.

Denomination of the stars	G			Lat. G.	Lat. M.	B./A.	Mag n.
	S.	.	M.				
The brighter star in the knot of both threads [Lucidior in nexu amborum linorum]	Υ	2	47 3 ½	9	4½	A	3

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
In the northern thread, preceding from the junction [In lino boreo à connexu praecedens]	Υ	2 2	12	1	38½	B	5.
The southern of the three after this one [Post hanc trium australis]	Υ	2 1	16	1	51½	B	5.
The middle and brighter in the northern knot [Media & lucidior in nexu boreo]	Υ	2 1	16	5	21	B	4.
The northern of three, and the last in the thread [Borea trium & ultima in lino]	Υ	2 1	36 ½	9	24	B	5
The northern of two in the mouth of the northern fish [Borea duarum in ore piscis borei]	Υ	2 3	15	22	0	B	6:
The southern [Australis]	Υ	2 2	49 ½	20	43	B	5
The northern star of the triangle, in the head [Borealis trianguli in capite]	Υ	1 9	22 ½	20	55	B	6.
The southern of the same triangle [Australis ejusdem trianguli]	Υ	1 8	6½	19	24	B	6
The middle and preceding of the triangle [Media & antecedens trianguli]	Υ	1 7	3½	20	24	B	6
Preceding, near the three in the southern spine [In australi spina trium praecedens prope]	Υ	1 7	56 ½	13	21	B	5
The middle one (the left elbow of Andromeda) [Media. (sinistrum cubitum	Υ	1 8	2½	12	21½	B	6

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
Andromedae)]							
The lowest of three [Infima trium]	Υ	1 8	9	11	21	B	6:
The northern of two in the belly [In alvo duarum borea]	Υ	2 3	18	17	26	B	5
The one further toward the south [Quae magis ad austrum]	Υ	2 0	58 ½	15	30	B	5
Following the middle of three in the southern spine [Sequens mediam trium in australi spina]	Υ	1 8	0	12	27½	B	5
Following the northern one in the belly, toward the north [Sequens boream in alvo ad Septent.] *	Υ	2 4	11	18	31	B	6
In the back of the head of the northern fish [In occipite borei piscis] *	Υ	2 1	41	23	3	B	6

SECOND, ON THE STARS THAT APPEAR TOWARD THE NORTH

URSA MINOR, CYNOSURA [Ursa Minor]

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./ A.	Mag n.
		.	M.				
At the very end of the tail, commonly the pole star [In extremo caudae, vulgo polaris]	Π	2 3	2½	66	2	B	2
The next-to-last in the tail [Penultima caudae]	Π	2 5	36	69	50½	B	4
The one at the root of the tail [Quae in caudae radice]	⊖	3	24	73	50	B	4
The upper of the two in the following quadrilateral	⊖	2 1	29	75	0	B	4

Denomination of the stars	G				Lat. M.	B./ A.	Mag n.
	S.	.	M.	Lat. G.			
[Superior duarum in □ sequentium]							
The lower of the same [Earundem inferior]	♄	2	52 4	7 [recte: 73?]	38½	B	5
The upper of the two in the preceding quadrilateral [Superior duarum in quadrato precedentium]	♄	7	16 ½	72	51½	B	2
The lower of the same [Earundem inferior]	♄	1	41 4	75	23½	B	2

URSA MAIOR, HELICE [Ursa Major]

Denomination of the stars	G			Lat. G.	Lat. M.	B./A.	Mag n.
	S.	.	M.				
The one on the snout [Quae in rostro]	♄	1	36 7 ½	40	2½	B	4
Below the left eye [Sub oculo sinistro]	♄	1	10 7	43	55½	B	4
Adjacent below this one [Contigua sub hac] *	♄	1	8 6	44	22	B	5
Above the right eye [Supra oculum dextrum]	♄	1	25 8	47	50½	B	4
Above the left eye [Supra oculum sinistrum]	♄	1	44 9 ½	47	44½	B	4
At the left ear [Ad aurem sinistram]	♄	2	42 4 ½	51	36½	B	5
The lowest, preceding, in the small triangle of the neck [Infima praecedens in parvo △ colli]	♄	2	50 3	42	30	B	5
The following one in the same triangle [Sequens in eodem triangulo]	♄	2	2 5	45	3	B	4
The topmost at the apex of the	♄	2	0	46	21½	B	5.

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
same triangle [Suprema in apice eiusdem $\triangle$] *			8				
On the neck, following the said triangle [In collo, dicto triangulo succedens]	α	0	38	42	36	B	4
Following below this one [Sequens infra hanc]	α	3	38 $\frac{1}{2}$	38	15 $\frac{1}{2}$	B	4:
On the left front knee [In genu sinistro anteriori]	α	0	32 $\frac{1}{2}$	34	34 $\frac{1}{2}$	B	3.
The more northern of two on the right foot [Duarum in dextro pede borealior]	β	2	56 5	29	15 $\frac{1}{2}$	B	3.
The more southern [Australior]	β	2	10 7	28	38	B	3.
Below the right knee [Infra genu dextrum]	β	2	7 7	33	30	B	5
On the right knee itself [In ipso genu dextro]	β	2	26 7	36	6	B	5
The upper of the preceding stars in the larger quadrilateral [Superior praecedentium in $\square$ majori]	α	9	34	43	40	B	2
The lower of the same quadrilateral [Inferior eiusdem $\square$]	α	1	43 3 $\frac{1}{2}$	45	3 $\frac{1}{2}$	B	2
The upper of the following stars of the quadrilateral [Superior sequentium quadrati]	α	2	25 5 $\frac{1}{2}$	51	37	B	2
The lower of the same [Inferior earundem]	α	2	45 4	47	6 $\frac{1}{2}$	B	2
The upper of the left hind foot [Superior sinistri pedis posteriorum]	α	1	56 3 $\frac{1}{2}$	29	51 $\frac{1}{2}$	B	4:
The following and more	α	1	4 $\frac{1}{2}$	28	45	B	4:

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
southern [Sequens & australior]			5				
On the knee of the preceding hind feet [In genu praecedentis pedum posterioro.]	♌	2	33	35	14	B	4
			2				
Preceding the two on the right hind foot [Praecedens duarum in dext. pede poste.]	♍	0	55	26	14	B	4:
The following and more southern [Sequens & australior]	♍	1	36	24	54	B	4:
The antepenultimate of the tail [Antepenultima caudae]	♍	3	10	54	18	B	2.
The next-to-last [Penultima]	♍	9	56	56	22	B	2
			$\frac{1}{2}$				

Ursa Major [Ursa Major] (conclusion)

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The last of the tail [Ultima caudae]	♍	2	12	54	25	B	2
			1				
Unformed, between this one's tail and Leo [informis inter caudam hujus & Leonis]	♍	1	43	40	6	B	2
			7 $\frac{1}{2}$				

DRACO [Draco]

Denomination of the stars	S.		G.	M .	Lat. G.	Lat. M.	B./ A.	M ag n.
The one on the tongue [Quae est in lingua]	♌		18	5	76	17	B	4.
				6				
				$\frac{1}{2}$				
In the mouth [In ore]	♐		4	1	78	14 $\frac{1}{2}$	B	4.
				4				
				$\frac{1}{2}$				
Preceding, of the two	♐		6	1	75	21	B	3

Denomination of the stars	S.	G.	M. .	Lat. G.	Lat. M.	B./ A.	M ag n.
bright stars in the head [Duarum lucidarum in capite praeced.]			9 ½				
The one at the cheek [Quae ad genam]	♂	19	3	80	21½	B	4
Following the bright ones (commonly the bright star of the head) [Sequens lucidarum (vulgo lucida cap.)]	♂	22	2 4	75	3½	B	3:
In the first bend of the neck, the northern of three [In prima colli inflexione trium boreal.]	♂	71 [recte: ?]	4	81	53	B	5:
The southern [Australis]	♂	24	3 1	77	57	B	5:
The middle of the same [Media earundem]	♂	20	3 3 ½	79	51½	B	5:
The one that follows toward the east [Quae sequitur ad ortum]	≈	9	2 9	80	53½	B	4.
The one near the second bend [Quae est prope secundam flexuram]	✕	28	3 3	81	51	B	4
The northern of the quadrilateral of the second bend [Borea	γ	12	2 6 ½	82	49	B	3.

Denomination of the stars	S.	G.	M. .	Lat. G.	Lat. M.	B./ A.	M ag n.
□ secundae flexurae]							
The northern of the following side [Borea lateris sequentis]	Υ	15	2 1	78	9½	B	4
The southern of the same side [Australis ejusdem lateris]	Υ	27	4 7	79	25	B	3.
Preceding, of the following triangle [Sequentis trianguli praecedens]	ϣ	15	1 8	83	5	B	4
The one that follows toward the south [Quae sequitur ad austrum]	Υ	19	4 0 ½	80	38	B	4.
The one above this [Quae supra hanc]	Υ	26	4 4	80	54	B	4:
Following in the remaining triangle [In reliquo triangulo sequens]	ϣ	6	3 4 ½	83	4½	B	4
The southern of the same [Australis ejusdem]	ϣ [with subscript]	1	2 8	83	28½	B	4
Preceding and the northern of the triangle [Praecedens ac borealis trianguli]	II	5	3 1	84	48½	B	4
The one in the bend of the third coil [Quae in flexura nodi tertij]	ϣ	29	4 4 ½	81	4½	B	3.
Nearest to the pole	ϣ	6	2	86	53	B	4

Denomination of the stars	S.	G.	M. .	Lat. G.	Lat. M.	B./ A.	M ag n.
of the zodiac [Polo Zodiaci proxima]			6				
The one that follows 24 [Quae 24. sequitur]	♏	28	2 1	83	18	B	5.
Succeeding this one [Succedens huic]	♏	28	2 2	81	41	B	5.
Nearer the pole, of moderate brightness [Polo vicinior, mediocriter lucida]	♏	26	5 1 ½	84	46	B	3
Preceding the antepenultimate, from the outermost bend [Praecedens antepenul. ab extr. flexione]	♏	7	5 5	78	23	B	3

Draco [Draco] (conclusion)

Denomination of the stars	S.	G . M.	Lat. G.	Lat. M.	B./A.	Mag n.
The antepenultimate, preceding the bend [Antepenultima flexuram praecedens]	♏	1 28 2 ½	74	11½	B	3.
The next-to-last, at the bend [Penultima ad flexuram]	♏	2 22 9	71	4	B	3
The one following the bend, the second [Quae flexuram sequitur, secunda]	♏	2 17 9	65	18	B	5
The one that follows the bend most closely [Quae flexuram proxime sequitur]	♏	2 10 ½	66	36	B	2.
The next-to-last of the tail [Penultima caudae]	♏	1 26 0	61	33	B	3

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The last of the tail [Ultima caudae]	♑	4	37 ½	57	7	B	3
Unformed, between [the last] and the arm of Cepheus [Inter 1. & brachium Cephei, inform.]	Υ	1	4	77	31½	B	5

CEPHEUS [Cepheus]

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
On the girdle [In Cingulo]	♊	0	13	71	7	B	3
The bright star on the shoulder [Lucida in humero]	Υ	7	13	68	54	B	2
The one on the left shoulder [Quae in sinistro humero]	Υ	2	53 7 ½	62	35	B	4
The one in the tiara that follows toward the north [Quae in tiara sequitur ad Boream]	Υ	8	29	61	3	B	4

BOOTES SEU ARCTOPHYLAX [Boötes, or Arctophylax]

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
Preceding, of three on the left hand [In manu sinistra trium praecedens]	♐	2	9½ 4	58	53	B	4.
The second [Secunda]	♐	2	33 5	58	51	B	4.
The third [Tertia]	♐	2	59 6 ½	60	5	B	4.
On the left elbow [In cubito sinistro]	♑	1	18	54	40	B	4
On the left shoulder [In humero sinistro]	♑	1	5½ 3	49	53½	B	3
On the head [In capite]	♑	1	43 8 ½	54	15½	B	3.

Denomination of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
On the right shoulder above the crown [In dextro humero supra coronam]	♌	2 7	29 ½	49	1	B	3
The one at the hip, under the right arm [Quae in coxendice sub brachio dextro]	♌	2 2	29 ½	40	40	B	3
The lower of two adjacent on the back [Inferior duarum contiguarum in dorso]	♌	1 8	16	42	11	B	4
The upper of the same [Superior earundem]	♌	1 7	17 ½	42	35½	B	4:
The one on the right leg [Quae est in crure dextro]	♌	2 7	26 ½	27	57	B	3
The topmost on the left shin [Suprema in tibia sinistra]	♌	1 3	42	28	9	B	3
The middle one [Media]	♌	1 2	25	26	33	B	4.
The lowest one [Infima]	♌	1 3	37	25	14	B	4:
On the hem of the tunic, called Arcturus [In fimbria tunicae, Arcturus dicta]	♌	1 8	39 ½	31	2½	B	1
The lowest of three unformed, near the right knee [Infima trium inform. circa dextr. genu]	♌	2 6	13 ½	30	27½	B	4

*

Book I, Chapter II — Catalogue of the Fixed Stars (epoch 1600), continued

Column rubric for every table below: **Designation of the stars [Denominatio stellarum]** | **Longitude [Longitudo]** (S. = sign, G. = degrees, M. = minutes) | **Latitude [Latitudo]** (G. = degrees, M. = minutes; **B.** = north [borealis], **A.** = south [australis]) | **Magn.** = magnitude. Zodiac-sign glyphs are given in the longitude

"S." column; an asterisk (*) in the designation column marks a star flagged in the source. Each numerical entry is transcribed exactly as printed.

Boötes / Arctophylax (Bootes), continued

The first two rows below complete the Boötes table begun on the preceding page.

Designation	S.	G M		Lat. G.	Lat. M.	B/ A	Magn .
The middle one [Media] *	♌	2	1	31	22	B	4
		7	1				
The topmost [Suprema] *	♌	2	5	33	52	B	4
		7	2				

CORONA BOREA, GNOSSIA (Corona Borealis, the Cretan Crown)

Designation	S.	G M		Lat. G.	Lat. M.	B/ A	Mag n.
The bright star of the Crown [Lucida Coronæ]	♌	6	38	44	23½	B	2:
			½				
The preceding one [Præcedens]	♌	3	37	46	8	B	4
The one above this [Supra hanc]	♌	3	10	48	25	B	5
			½				
The one following more toward the north [Quæ succedit magis septentrion. versus]	♌	8	2	50	21	B	6
The one following the bright star [Quæ sequitur lucidam]	♌	9	14	44	33	B	4
			½				
The next following [Proximè sequens]	♌	1	25	44	52	B	4
			1				
The one that again accompanies this [Quæ hanc rursus comitatur]	♌	1	32	46	9½	B	4
			3				
The last of all [Omnium ultima]	♌	1	2	48	24	B	6.
			3				

Star count: 8.

HERCULES, EN GONASI (Hercules, the Kneeler / Engonasin)

Designation	S.	G		Lat. G.	Lat. M.	B /		Magn.
		.	M.			A		
In the head [In capite]	♄	1	31 0	37	23	B		3:
In the right shoulder [In humero dextro]	♍	2	27 5 ½	42	48	B		3
The next-to-last in the right arm [Penultima dextri brachij]	♍	2	36 3	40	5½	B		3.
The lowest in the right arm [Infima in dextro brachio]	♍	2	6½ 0	37	19	B		4:
In the left shoulder [In sinistro humero]	♄	9	10	47	47	B		3
In the left arm [In sinistro brachio]	♄	1	22 4	49	23	B		4.
The preceding one in the Lion's spoils [Præcedens in exuuijs Leonis]	♄	1	36 9	51	16½	B		4:
The following one in the triangle of the spoils [Sequens in triangulo exuuiarum]	♄	2	19 7	52	19	B		4.
In the base of the triangle, toward the north [In basi trianguli ad boream]	♄	2	57 3	53	46	B		4.
The middle of those in the spoils [Media earum quæ in exuuijs]	♄	2	38 3	52	47	B		4.
The one in the left hip [Quæ est in coxa sinistra]	♍	2	2 6	53	10½	B		3
More to the east than this, in the left thigh [Hac orientaliior, in femore sinistro]	♄	2	45 ½	53	21	B		3.

Designation	S.	G		Lat. G.	Lat. M.	B /		Magn.
		.	M.			A		
The preceding of three adjacent ones in the thigh [Præcedens trium contiguarū in femore]	↗	6	21½	59	38	B		4
The middle one [Media]	↗	7	19	60	11½	B		4
The following one [Sequens]	↗	9	47½	60	13½	B		4
In the left knee [In genu sinistro]	↗	2	562	60	47	B		3
The one in the left leg, near the head of Draco [Quæ in sinistra sura prope caput Draco.]	↗	1	174	63	22	B		3
The preceding of three faint stars in the left foot [Præcedens trium obscurarū in pede sini.]	↗	7	5½	71	20	B		6.
The middle of the same [Media earundem]	↗	1	71	71	3½	B		6.
The last [Ultima]	↗	1	08	71	5	B		neb. [ne(bulosa)]
In the upper right thigh [In superiori femore dextro]	ℳ	2	8½3	60	22½	B		3
More to the north, in the same thigh [Borealior in eodem femore]	ℳ	1	397½	63	14	B		4
The one in the right knee [Quæ est in dextro genu]	ℳ	8	43½	65	55	B		4
The one in the upper leg [Quæ est in superiori sura]	ℳ	5	57	63	51	B		4
The one in the lower leg [Quæ in crure]	ℳ	2	43	64	23	B		4
The preceding one in the	ℳ	1	32	62	29	B		5

Designation	S.	G		Lat.	G.	Lat.	M.	B	/	Magn.
right lower leg [Præcedens in dextro crure] *		6								
The one in the shin of the right foot, near the ankle [Quæ in tibia dextri pedis circa talum]	♄	2	28 ½	60		15½		B		4:
The outermost in the right foot [Extrema in dextro pede]	♅	2	6 7	57		15½		B		4

Star count: 28.

LYRA (Lyra)

Designation	S.	G		Lat.	G.	Lat.	M.	B/	A	Mag	n.
The bright star of the Lyre [Lucida Lyræ]	♄	9	43	61		47½		B		1	
The one above the bright star, toward the north wind [Quæ supra lucidam ad aquilonem]	♄	1	14 3	62		27		B		5:	
The one below the bright star, toward the east-southeast [Quæ infra lucidam ad eorum]	♄	1	26 2	60		26		B		5:	
The one in the middle of the spread of the horns [Quæ in medio educationis cornuum]	♄	1	10 6 ½	59		26		B		4.	
Of the two adjacent, toward the north [Duarum contiguarum ad boream]	♄	2	32 4 ½	60		46		B		5:	
The one toward the south [Quæ ad austrum]	♄	2	2 5	59		41		B		5	
Of the two preceding ones in the crossbar, the northern [Duarum præcedentium in jugo, borea]	♄	1	16 3 ½	56		5		B		3	

Designation	S.	G . M.	Lat. G.	Lat. M.	B/ A	Mag n.
The small star beneath this [Parua sub hac]	♄	1 3½ 3	55	16	B	6
In the crossbar, the northern of two following [In iugo, duarum sequentium borea]	♄	1 11 6	55	6	B	3
The small one that lies beneath this [Parua, quæ huic subest]	♄	1 20 6	54	31½	B	6
The one almost in the middle of the body [Quæ in medio ferè corpore] *	♄	2 52 0	58	6	B	5

Star count: 11.

CYGNUS (Cygnus, the Swan)

Designation	S.	G . M.	Lat. G.	Lat. M.	B/ A	Mag n.
In the beak [In rostro]	♄	2 44 5	49	2	B	3
In the head [In capite]	♄	2 20 9	50	42	B	5
In the middle of the neck [In medio colli]	♁	7 33	54	19	B	4
In the breast [In pectore]	♁	1 25 9	57	9½	B	3:
In the tail [In cauda]	♁	2 53 9 ½	59	56½	B	2:
The first and brightest in the upper elbow-joint of the wing [Prima & lucidiss. in ancone superio. alæ]	♁	1 53 0	64	28	B	3
Of three in the upper palm, the southern [Trium in superiori vola, australis]	♁	1 21 3	69	42	B	4.
The next-to-last of the upper wing	♁	1 39	71	31	B	4

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
		.	M.				
[Penultima superioris alæ]		2	1½				
The outermost of the upper wing [Extrema superioris alæ]	≈	9	36 1½	73	50½	B	4.
The one in the elbow-joint of the lower wing [Quæ in ancone inferioris alæ]	≈	2 2	9½	49	26	B	3.
In the middle of it [In medio ipsius]	≈	2 4	18	51	41	B	4
The outermost of the lower wing [Extrema inferioris alæ]	≈	2 7	43	43	44	B	3.
The preceding one in the lowest foot [Præcedens in in fimo pede]	✕	0	32	54	59	B	4
The one following in the lowest knee [Quæ sequitur in infimo genu]	✕	5	21 1½	56	36	B	4:
Of two adjacent in the upper foot, the southern and preceding [Aust. & præc. duarū contig. in sup. pede]	≈	2 2	50	63	37	B	4
Following the same, and more to the north [Sequens earundem & borealior]	≈	2 4	34 1½	64	17½	B	4
The interior of two, following the lower right wing [Interior duarū infor. dex. alam sequens]	✕	3	3½	50	33	B	4.
The upper of the same [Superior earundem]	✕	4	53 ¾	51	31	B	4

Star count: 18.

CASSIOPEA (Cassiopeia)

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
		.	M.				
In the head [In capite]	Υ	2	35	44	40½	B	4

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
		9					
In the breast, Schedir [In pectore, Schedir]	☿	2	17 ½	46	35½	B	3:
In the girdle [In cingulo]	☿	4	58	47	5	B	4
In the bend at the haunches [In flexura ad coxas]	☿	8	27 ½	48	46	B	3:
At the knee [Ad genu]	☿	1	21	46	22	B	3
		2					
In the lower leg [In crure]	☿	1	13	47	29	B	3
		9	½				
The outermost of the foot [Extrema pedis]	☿	2	39	48	54	B	4
		6					
In the left arm [In brachio sinistro]	☿	6	14 ½	43	6	B	4
In the left elbow [In cubito sinistro]	☿	5	16	43	28	B	5
In the right elbow [In cubito dextro]	♃	2	39	49	24½	B	6
		4					
In the upright part of the seat [In erectione sedis]	☿	7	6	52	14	B	4
The bright star of the chair [Lucida cathedræ]	♃	2	35	51	14½	B	3
		9	½				
The outermost of the chair [Extrema cathedræ]	♃	2	34	51	8	B	6
		5					
The one next to this, at the extremity of the seat [Quæ iuxta hanc ad extremitatē Sellæ] *	♃	2	32	52	39	B	6
		5					
The one in an almost straight line with the 11th and 17th [Quæ in recta ferè linea cum XI. & XVII.] *	☿	1	28	52	48	B	6
		9					
The outermost of the footstool [Extrema scabelli] *	☿	2	21	56	13	B	6
		2					
The middle of the footstool	☿	2	33	54	27	B	6

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
[Media scabelli] *		2					
In the footstool, nearest to the sole of the foot [In scabello proximè ad plantam pedis] *	♄	2 1	58	52	8½	B	6
The one that follows the knee [Quæ genu sequitur] *	♄	1 2	57 ½	44	57½	B	6
The one that precedes the knee [Quæ genu præcedit] *	♄	1 0	0	45	4½	B	6
The circle of the navel [Girus Umbilici] *	♄	6	52	47	31½	B	6
The little one near the hair of Cassiopeia [Paruula ad crines Cassiopeæ] *	♄	2 9	10	45	38	B	6
Following, one of two northern ones in the rod [Sequens ex duabus borealib? in virga] *	♄	2 9	32	41	15	B	6
Preceding the same [Præcedens earundem] *	♄	2 7	57	41	25½	B	6
The next-to-last of the rod [Penultima virgæ] *	♄	2 6	56	39	15½	B	6
The outermost of the rod [Extrema virgæ] *	♄	2 5	54 ½	38	9	B	6

Star count: 26.

PERSEUS (Perseus)

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
In the outermost turning of the right hand [In extrema dextræ manus obuolutione]	♄	1 8	31	39	0½	B	6
In the right elbow [In cubito dextro]	♄	2 3	9½	37	28½	B	4
In the right shoulder [In dextro]	♄	2	26	34	30	B	3

Designation	S.	G		Lat. G.	Lat. M.	B/ A	Mag n.
		.	M.				
humero]		4	½				
The one in the left shoulder [Quæ in sinistro humero]	♊	1 9	4½	31	34½	B	4
The one at the crown of the head [Quæ in capitis vertice]	♊	2 1	50	34	26½	B	5
The one in the back [Quæ in dorso est]	♊	2 3	33	30	36½	B	4.
The blazing one in the right side [Fulgens in dextro latere]	♊	2 6	17	30	5	B	2
The one that follows next below [Quæ proximè infra sequitur]	♊	2 7	4½	27	59	B	5
The small one following this [Hanc sequens parua]	♊	2 8	13 ½	27	55	B	5:
The one at the bend of the same side [Quæ est ad flexuram eiusdem lateris]	♊	2 9	15	27	14	B	3.
The one in the left elbow [Quæ in cubito sinistro]	♊	2 2	6	26	4	B	4.
The head of Medusa, or Algol [Caput Medusæ, seu Algol]	♊	2 0	37	22	22	B	3

This Perseus table is incomplete; it continues on the following page (catchword "Quæ").

Book I, Chapter II — Catalogue of the Fixed Stars (epoch 1600), continued

Column rubric throughout: **Denomination of the stars** | **Longitude** (S. = sign / G. = degrees / M. = minutes) | **Latitude** (G. = degrees / M. = minutes; B. = north / A. = south) | **Magnitude**. Zodiac-sign glyphs are rendered with their sign name in the longitude "Sign" column.

Perseus (continued)

[The table continues the Perseus constellation begun earlier. Page header: "DE NOVA STELLA ANNI 1572." p. 267.]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
The star beneath Algol [Algol]	Tauru s	2 0	31	20	54	B (N)	5
The one preceding it	Tauru s	1 9	18	20	33	B (N)	4
Preceding, toward the north, in the same head	Tauru s	1 8	20	21	35	B (N)	4
In the right ham (back of the knee)	Gemi ni	6 $\frac{1}{2}$	13	28	22½	B (N)	5
The one that precedes the right knee	Gemi ni	4 $\frac{1}{2}$	11	28	50	B (N)	4
Preceding the bend of the knee	Gemi ni	3	55	26	11	B (N)	5
The middle one in the right knee	Gemi ni	5	14	26	39	B (N)	4
The one below the right knee	Gemi ni	6 0		24	35	B (N)	6
The one in the sole of the right foot	Gemi ni	8 1		18	56	B (N)	5
The one in the left thigh	Tauru s	2 8	11	22	6	B (N)	4
The one in the left knee	Gemi ni	0 8		19	4	B (N)	3
In the left shin	Tauru s	2 9	23 $\frac{1}{2}$	14	53½	B (N)	5
The one in the heel of the left knee	Tauru s	2 5	33	12	8	B (N)	4
Following the left foot	Tauru s	2 7	36	11	17½	B (N)	3
Unformed, above the head	Tauru	2	45	42	26	B	5

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
[marked *]	s	6				(N)	
The one in the upper part of the right thigh	Gemi ni	2	32	29	31	B (N)	5
Unformed, preceding the head of Medusa	Tauru s	1	16	20	53	B (N)	4

Star-count for Perseus on this page: 17 rows (continuation; full constellation total not printed here).

ERICHTHONIUS [Auriga / the Charioteer]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Ma gn.
		.	M.				
The upper and preceding of the two in the head	Gem ini	2	38	32	15	B (N)	6
The lower and following	Gem ini	2	14	30	50	B (N)	4
The bright star shining in the left shoulder, Capella [Capella]	Gem ini	1	16	22	51½	B (N)	1
The bright one in the right shoulder	Gem ini	2	18 [recte 12?]	21	27½	B (N)	2
In the right arm	Gem ini	2	59	13	44	B (N)	4
The one in the left elbow	Gem ini	1	9	20	52	B (N)	4
The preceding Kid (hædus)	Gem ini	1	5½	18	8½	B (N)	4
The following of the Kids (hædi)	Gem ini	1	49½	18	11½	B (N)	4
In the upper foot	Gem ini	1	4½	10	22	B (N)	4

Star-count for Erichthonius (Auriga) on this page: 9 rows; the constellation continues beyond this page (no "Numerus stellarum" total printed here).

COMA BERENICES [Coma Berenices / Berenice's Hair]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
At the apex of the first and northern triangle	Vir o	1 8	17 ½	28	25	B (N)	3
The upper one contiguous to this, toward the south following [*]	Vir o	1 8	42	27	23½	B (N)	4
The lower of the same [*]	Vir o	1 8	46 ½	27	20	B (N)	4
The one that follows the two contiguous [*]	Vir o	1 9	19	27	7	B (N)	4
Preceding the two southern contiguous ones	Vir o	1 8	25	25	51	B (N)	4
The other, contiguous, toward the east	Vir o	1 8	48 ½	26	7	B (N)	4
The one preceding all, toward the south [*]	Vir o	1 8	0½	23	30	B (N)	4
The highest of the three contiguous following ones [*]	Vir o	2 1	10	25	16	B (N)	4
The other and preceding [*]	Vir o	2 0	51 ½	24	56	B (N)	4
The lowest and following [*]	Vir o	2 2	52	24	0½	B (N)	4
The last in the extension of the hair (coma) [*]	Vir o	2 8	58 ½	32	46	B (N)	4
The one that precedes this [*]	Vir o	2 7	49 ½	31	41½	B (N)	4
The one between these and the first at the apex [*]	Vir o	2 4	17	30	16	B (N)	4
The one in the southern apex of the small triangle [*]	Vir o	2 8	15	28	32	B (N)	5

Star-count for Coma Berenices: 14 rows (no "Numerus stellarum" total printed).

OPHIUCHUS [Ophiuchus / Serpentarius]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
In the head	Sagittarius	1 6	50	35	57	B (N)	3
In the right shoulder	Sagittarius	1 9	45	28	1	B (N)	3
The lower and following one in the right shoulder	Sagittarius	2 1	5	26	11	B (N)	3
Preceding, in the left shoulder	Sagittarius	4 $\frac{1}{2}$	59	32	35½	B (N)	4
Following, in the same shoulder	Sagittarius	6	16	31	56	B (N)	4
The one in the left elbow	Sagittarius	0	3	23	39½	B (N)	4
In the left hand, the more northern	Virgo	2 6	44 $\frac{1}{2}$	17	19	B (N)	3
The following and more southern	Virgo	2 7	57	16	30½	B (N)	3
In the right elbow	Sagittarius	1 9	3	15	19	B (N)	4
The more southern and preceding, in the right hand	Sagittarius	2 4	13 $\frac{1}{2}$	13	47	B (N)	4
The more northern and following, in the same hand	Sagittarius	2 5	14 $\frac{1}{2}$	15	20	B (N)	5
In the right knee	Sagittarius	1 2	24	7	18	B (N)	3

OPHIUCHUS (continued)

Denomination of the stars	Sign	G M		Lat. G.	Lat. M.	N/S	Mag n.
		.	.				
The one in the left knee	Sagittarius	3 9	3	11	30	B (N)	3
In the right shin	Sagittarius	1 4	2 3	2	12	B (N)	3

Denomination of the stars	Sign	G M		Lat. G.	Lat. M.	N/S	Mag n.
		.	.				
The fifth of the unformed ones, in the Milky Way	Sagittarius	2	3	33	2½	B (N)	4
		6	1				

Star-count for Ophiuchus (total across both pages): 15 rows (no "Numerus stellarum" total printed).

SERPENS [the Serpent]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
Preceding, in the mouth	Virgo	1	35	38	12	B (N)	5
		1					
The one that is in the mouth	Virgo	1	24	39	6½	B (N)	3
		4	½				
The one in the temples	Virgo	1	6½	35	25	B (N)	3
		7					
In the drawing-out of the neck	Virgo	1	21	34	27½	B (N)	3
		4	½				
The one at the left eye	Virgo	1	10	37	28½	B (N)	4
		5					
The one at the nostrils	Virgo	1	32	42	37	B (N)	4
		6					
The second on the neck, below the head	Virgo	1	46	28	58	B (N)	3
		2	½				
In the middle of the coil of the neck	Virgo	1	30	25	35½	B (N)	2
		6					
The more southern of the three	Virgo	1	46	24	5½	B (N)	5
		8	½				
The one that is in the second bend	Virgo	2	26	16	26½	B (N)	4
		0	½				
The third-from-last of the tail	Sagittarius	2	34	19	57	B (N)	3
		4	½				
The next-to-last	Capricorn	0	12	20	37½	B (N)	3
		½					
The last	Capricorn	1	10	26	59	B	3

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
		0				(N)	

Star-count for Serpens: 13 rows (no "Numerus stellarum" total printed).

SAGITTA [the Arrow]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
The upper and more eastern	Aquarius	1	32	39	13	B (N)	4
The middle, or the one preceding this	Capricorn	2	55 7	38	58½	B (N)	5
The little one above the middle	Capricorn	2	31 8	39	31	B (N)	6
The upper of the two contiguous ones, in the notch (Glyphis)	Capricorn	2	30 5 ½	38	53	B (N)	4
The lower of the same	Capricorn	2	39 5	38	18	B (N)	4

Star-count for Sagitta: 5 rows (no "Numerus stellarum" total printed).

VULTUR [Aquila / the Eagle; "Vultur" = the Vulture]

Denomination of the stars	Sign	G M		Lat. G.	Lat. M.	N/S	Mag n.
		.	.				
The one in the head	Capricorn	2	2 9 ½	27	8½	B (N)	6
In the neck	Capricorn	2	5 6 3	26	49½	B (N)	3
The bright one in the shoulder-blades	Capricorn	2	9 6	29	21½	B (N)	2

VULTUR (Aquila, continued)

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
The small one above the	Capricorn	2	33	30	54½	B	6

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
bright star	n	5				(N)	
The one in the left shoulder	Capricor n	2	26	31	18	B (N)	3
The one that follows, small	Capricor n	2	8½	31	59	B (N)	5
The upper and preceding, in the lower wing	Capricor n	2	16 1 ½	28	46½	B (N)	4
The lower and following, in the wing	Capricor n	2	14	26	35	B (N)	5
The tail of the Vulture	Capricor n	1	15 4 ½	36	16½	B (N)	3
The one that next precedes the tail, unformed	Capricor n	1	44 2	37	40	B (N)	3
The middle of the unformed ones above the tail	Capricor n	9	12	43	32½	B (N)	4
The seventh of the unformed, which follows out of the three	Capricor n	9	17 ½	41	5	B (N)	4

Star-count for Vultur (Aquila), total across both pages: 12 rows (no "Numerus stellarum" total printed).

ANTINOUS [Antinous]

Denomination of the stars	Sign	G		Lat. G.	Lat. M.	N/S	Mag n.
		.	M.				
The left hand	Capricor n	2	21 9 ½	18	48	B (N)	3
The right side	Capricor n	2	17 0 ½	20	14½	B (N)	3
The knee	Capricor n	1	17 9	14	28	B (N)	3

Star-count for Antinous: 3 rows (no "Numerus stellarum" total printed).

DELPHINUS [the Dolphin]

Denomination of the stars	Sign	G . M.	Lat. G.	Lat. M.	N/S	Mag n.
The bright one of the tail	Aquarius	8 32	29	8	B (N)	3
The one that follows the tail	Aquarius	9 48	28	52½	B (N)	6
The one below the tail	Aquarius	9 42	27	34	B (N)	6
In the rhomboid, preceding, the more southern of the side	Aquarius	1 56 0	31	57½	B (N)	3
The more northern of the same side	Aquarius	1 50 1 ½	33	5	B (N)	3
The more southern of the following side	Aquarius	1 36 3 ½	32	0	B (N)	3
The one that is in the head	Aquarius	1 52 3	32	47	B (N)	3
The one in the preceding side, the 4th, contiguously in front	Aquarius	1 17 0	32	8½	B (N)	5
Preceding the two, the lowest in the rhomboid	Aquarius	9 18	30	41½	B (N)	6
Following the same	Aquarius	1 42 0	30	41	B (N)	6

Star-count for Delphinus: 10 rows (no "Numerus stellarum" total printed).

EQUULEUS [the Foal / Little Horse]

Denomination of the stars	Sign	G . M.	Lat. G.	Lat. M.	N/S	Mag n.
Preceding, of the head	Aquarius	1 32 7 ½	20	12½	B (N)	4
Following, of the head	Aquarius	1 54 9 ½	21	6	B (N)	4

Star-count for Equuleus: 2 rows; the constellation continues beyond this page (no "Numerus stellarum" total printed here).

Book I, Chapter II — Catalogue of the Fixed Stars (epoch 1600), continued

The table columns are: **Denominatio stellarum** (designation of the stars) | **Longitudo** (longitude: S. = sign, G. = degrees, M. = minutes) | **Latitudo** (latitude: G. = degrees, M. = minutes; B. = *borealis*, north / A. = *australis*, south) | **Magn.** (magnitude). Zodiacal-sign glyphs are given by their standard names.

Equuleus (concluded)

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The one preceding, of the muzzle [Praecedens oris]	Aquarius	1	45	25	16	B	4
	s	7					
The one following, of the muzzle [Sequens oris]	Aquarius	1	54	24	52	B	4
	s	8	½				

PEGASVS [Pegasus]

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The mouth of Pegasus [Os Pegasi]	Aquarius	2	22	22	7½	B	3
	s	6					
The head [Caput]	Pisces	1	15	16	25	B	4:
			½				
The one toward the south in the head [Quae ad austrum in capite]	Aquarius	2	45	15	43	B	5.
	s	9	½				
The lower and following one in the mane [Inferior & sequens in juba]	Pisces	1	0	14	30½	B	6
		3					
The upper and preceding one in the mane [Superior & praecedens in juba]	Pisces	1	44	15	43½	B	6.
		2					
The bright star of the neck	Pisces	1	39	17	41	B	2

Denominatio stellarum	S.	G . M.	Lat. G.	Lat. M.	B./A.	Mag n.
[Lucida colli]		0 ½				
The following one in the neck [Sequens in collo]	Pisces	1 25 2	18	29	B	5
The left leg [Sinistrum crus]	Pisces	3 23	36	42⅞	B	4
The left knee [Sinistrum genu]	Pisces	8 50	34	19	B	4
The right leg [Dextrum crus]	Pisces	1 3 4	41	0½	B	4
The preceding of the two in the breast [Praecedens duarum in pectore]	Pisces	1 29 7 ½	28	49	B	4.
The following one [Sequens]	Pisces	1 53 8 ½	29	24½	B	4.
The right knee [Dextrum genu]	Pisces	2 10 0 ½	35	7½	B	3
In the same knee, toward the south [In eodem genu ad austrum]	Pisces	1 25 9	34	24½	B	5
The preceding of the two in the wing [Praecedens duarum in ala]	Pisces	2 33 5	25	35	B	6
The following one in the wing, and more to the south [Sequens in ala, & australior]	Pisces	2 6 7	24	50½	B	6
The first of the wing, Markab [Prima alae, Marchab]	Pisces	1 56 7 ½	19	26	B	2
The drawing-out of the leg, Scheat [Eductio cruris, Scheat]	Pisces	2 49 3 ½	31	7½	B	2
The end of the wing [Extrema alae]	Aries	3 38	12	35	B	2

ANDROMEDA

Denominatio stellarum	S.	G. .	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The head [Caput]	Aries	8	47	25	42	B	2
The lowest one in the right shoulder-blade [Infima in scapula dextra]	Aries	1	6½ 7	27	6½	B	5
The lower one in the left shoulder [Inferior in sinistro humero]	Aries	1	25 5	23	3½	B	4
In the right arm, the more southern of three [In dextro brachio trium australior]	Aries	1	58 4	31	33	B	5
The northern one [Borea]	Aries	1	45½ 5	33	20½	B	2

ANDROMEDA (continued)

Denominatio stellarum	S.	G. .	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The middle one [Media]	Aries	1	7 6	32	14½	B	5.
The more southern, in the upper hand [Australior, in superiori manu]	Aries	1	28 0	40	50½	B	4
The more northern [Borealiior]	Aries	1	46 1	41	44	B	4
The faint one in the same place [Obscura ibidem]	Aries	1	23 4	42	8	B	5.
The highest of all, in the northern hand [Suprema omnium in boreali manu]	Aries	1	47 2	43	49½	B	4
The preceding and upper of the two in the left arm [Praecedens & sup. duarum in sin. brachio]	Aries	1	9 5	17	48	B	4

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The one in the left elbow [Quae in sinistro cubito]	Aries	1	53 6 ½	15	58	B	5
The more southern one in the girdle [Australior in cingulo]	Aries	2	49 4	25	59	B	2
The middle one [Media]	Aries	2	6½ 4	30	33½	B	4:
The northern one [Borea]	Aries	2	36 3	32	3½	B	4
The bright one in the southern foot [In australi pede lucida]	Tauru s	8	39	27	46½	B	2
The outermost one in the upper foot [Extrema in superiori pede] *	Tauru s	9	6½	36	49'	B	4
The brighter, preceding one in the right foot [Lucidior & praecedens in dextro pede]	Tauru s	6	52	35	21½	B	4
The highest one in the left calf [Suprema in sinistra sura]	Tauru s	5	6	28	59	B	5
The lower one [Inferior]	Tauru s	3	23	27	54½	B	5.
The one toward the right knee [Quae ad genu dextrum]	Tauru s	0	56	36	20	B	5.
The one at the ring at the end of the Chain [Quae est in extremo Catenae annulo] *	Pisces	2	0 4	57	19	B	4
The brighter and upper one in the left shoulder-blade [Clarior & superior in sinistra scapula]	Aries	1	19 6 ½	24	20	B	3

TRIANGVLVS [Triangulum]

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
At the apex of the triangle [In	Tauru	1	19	16	49½	B	4

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
apice trianguli]	s	.	M.				
At the base, toward the north [In basi ad boream]	Tauru s	6	49 ½	20	33	B	4
The middle one [Media]	Tauru s	7	59	19	29	B	5
The more southern one at the base [Australior in basi]	Tauru s	7	58	18	57	B	4

THIRD: ON THE STARS THAT ARE SEEN IN THE SOUTHERN REGION [TERTIO, DE STELLIS QVÆ IN MERIDIONALI PARTE VIDENTVR]

CETE [Cetus]

Denominatio stellarum	S.	G M		Lat. G.	Lat. M.	B./A.	Mag n.
The one in the snout [Quae in rostrō]	Tauru s	9	3 1	7	50	A	4

CETE [Cetus] (continued)

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
The bright star of the jaw of Cetus [Lucida mandibulae Cete]	Tauru s	8	47	12	37	A	2
The middle one in the mouth [Media in ore]	Tauru s	3	52 ½	12	2½	A	3
The preceding of three at the cheek [Praecedens trium ad genam]	Tauru s	2	2	14	32	A	3
The one below the eye [Quae infra oculum]	Tauru s	1	54	5	52	A	4
The one above the eye [Quae	Tauru	6	7	5	36	A	4

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
est supra oculum]	s						
In the back of the head [In occipite]	Aries	2 8	29 ½	4	19	A	4.
In the breast of the quadrilateral, the preceding northern one [In pectore quadrilateri praecedent. borea]	Aries	2 4	9	25	17	A	4
Of the two lower ones preceding, toward the south [Duarum infer. praecedentium ad austrum]	Aries	2 4	31 ½	28	31	A	4
The southern of those following in the breast [Sequentium in pectore australis]	Aries	2 8	11 ½	28	16½	A	4
The preceding and northern one [Praecedens & borealis]	Aries	2 7	47 ½	25	58	A	3.
The middle one in the belly [In ventre media]	Aries	1 2	25	25	1	A	4.
The lowest one in the belly [Infima in ventre]	Aries	1 3	50	31	4	A	4.
The northern one of the belly [Borea ventris]	Aries	1 6	25	20	19	A	3:
The more eastern of two brighter ones in the back [Duarum lucidiorum in dorso orientalior]	Aries	1 0	42 ½	15	46½	A	3.
The more western of the same [Occidentalior earundem]	Aries	6 ½	11	16	55	A	3.
The northern one of the tail [Borealis caudae]	Pisces	2 5	23	10	1	A	3
The southern, or bright, star of the tail [Australis seu lucida caudae]	Pisces	1 6	56	20	47	A	2

Denominatio stellarum	S.	G .	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The bright star of the jaw, following toward the east, lower [Lucida mandib. ad ortum sequens infor.] *	Tauru s	1 2	45	14	30	A	5.
The one preceding the northern part of the belly, toward the south [Boream ventris praecedens ad austrum] *	Aries	1 5	4½	21	55	A	5:
The one in a straight line with the 3rd and 5th [stars] of [the head of] Cetus [Quae in recta linea cum III. & v. Cap.] *	Tauru s	2 ½	49 ½	9	12½	A	4

ORION

Denominatio stellarum	S.	G .	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The highest of three joined together in the head [Suprema trium coniunctarum in capite]	Gemi ni	1 8	11 ½	13	26	A	4.
The more western one [Occidentalior] *	Gemi ni	1 8	6½	13	54	A	5
The third, which is toward the east [Tertia quae ad ortum] *	Gemi ni	1 8	33 ½	14	4½	A	5
The following, or the bright shoulder [Sequens, seu lucidus humerus]	Gemi ni	2 3	12	16	6	A	2:
The left, or preceding shoulder [Sinister, seu praecedens humerus]	Gemi ni	1 5	23	16	53	A	2.
The following one in the left shoulder [Sequens in sinistro humero]	Gemi ni	6	47	17	22	A	5
The one in the right arm	Gemi	2	4½	14	31	A	4

Denominatio stellarum	S.	G . M.	Lat. G.	Lat. M.	B./A.	Mag n.
[Quae in dextro brachio]	ni	5				

ORION (continued)

Denominatio stellarum	S.	G . M.	Lat. G.	Lat. M.	B./A.	Mag n.
In the right forearm [In dextra ulna]	Gemi ni	2 30 8 ½	11	30	A	6
In the right hand, more to the south [In manu dextra australior]	Gemi ni	2 23 7 ½	9	15	A	4
The preceding one in the right hand [Praecedens in dextra manu]	Gemi ni	2 21 6	8	44	A	4.
The one next to the highest in the right hand [Proxima supremae in dextra manu]	Gemi ni	2 22 7	7	20½	A	6
The highest and last of those in the hand [Suprema & ultima earum quae in manu]	Gemi ni	2 8½ 8	7	19	A	6
The preceding of two in the lopped extremity [Praecedens duarum in coloboro]	Gemi ni	2 9 3	3	12½	A	5
The following of the same [Sequens earundem]	Gemi ni	2 21 5 ½	3	21	A	5
The one that is below the right shoulder, toward the west [Quae est infra dext. humerum ad occasum]	Gemi ni	1 56 8 ½	19	17½	A	5.
Of two faint ones in the back, the following one [Ex duabus obscuris in dorso sequens]	Gemi ni	1 40 7	19	36½	A	6.
The preceding of the same [Praecedens earundem]	Gemi ni	1 46 6	19	52½	A	6.
The one of four in the back	Gemi	1 34	20	8½	A	5

Denominatio stellarum	S.	G .	M.	Lat. G.	Lat. M.	B./A.	Mag n.
that precedes [Quae ex quatuor in dorso praecedit]	ni	5					
Of the nine in the shield, the most northern [In clypeo novem borealissima]	Gemi ni	7	53	8	17	A	4
The second [Secunda]	Gemi ni	8	48	9	7	A	4.
The third [Tertia]	Gemi ni	8	10	11	6	A	6
The fourth [Quarta]	Gemi ni	8	0½	12	25½	A	4
The fifth [Quinta]	Gemi ni	6	49	13	31½	A	4
The sixth [Sexta]	Gemi ni	6	23	15	27	A	4
The seventh [Septima]	Gemi ni	6	33	16	50	A	4
The eighth [Octava]	Gemi ni	6	58	20	2	A	4:
The last [Ultima]	Gemi ni	7	57	20	55½	A	4
The first of the belt [Prima baltei]	Gemi ni	1	50 6 ½	23	38	A	2
The middle one [Media]	Gemi ni	1	54 7	24	33½	A	2
The last [Ultima]	Gemi ni	1	6½ 9	25	21½	A	2.
The one in the hilt of the sword [Quae in manubrio ensis]	Gemi ni	1	37 4 ½	25	36½	A	3
The highest of three in the sword [Suprema trium in ense]	Gemi ni	1	28 7	28	9½	A	5
The middle one of the sword	Gemi	1	24	28	45	A	3.

Denominatio stellarum	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
[Media ensis]	ni	7	½				
The southern one [Australis]	Gemi ni	1	27 7 ½	29	17	A	3
The preceding of two below the sword [Praecedens duarum infra ensem]	Gemi ni	1	20 6	30	37½	A	4.

Book I, CAPVT SECVNDVM — Star catalogue for the epoch 1600, southern region (continued). Column rubric: DENOMINATIO STELLARVM (description of the stars) | LONGITVDO (S. = sign, G. = degrees, M. = minutes) | LATITVDO (G. = degrees, M. = minutes; B. = north, A. = south) | MAGN. (magnitude). Signs are given by the zodiacal glyphs (♊ = Gemini, ♋ = Cancer, ♌ = Leo, ♍ = Virgo, ♎ = Libra). All latitudes here are marked A. (south).

ORION (continued)

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The following of two below the sword [Sequens duarum infra ensem]	♊	1	23 8	30	38	A	5
The bright one in the left foot, Rigel [Lucida in sinistro pede, Regel]	♊	1	17 1	31	11½	A	1.
The one in the left heel [Quae in sinistro calcaneo]	♊	1	15 2 ½	29	53	A	4
The one in the calf of the left foot [Quae in sura sinistri pedis]	♊	1	2 4	31	0	A	5:
In the right knee [In genu dextro]	♊	2	49 0 ½	33	8	A	3
The one that the belt's last star precedes, toward the south [Quae ultimam baltei praecedit ad austrum] *	♊	1	39 8	26	0½	A	4
The one on the back, preceding this last [Quae ad dorsum est,	♊	1	34 4	19	40	A	6

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
hanc praecedens]							

ERIDANVS [Eridanus]

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The one at the left foot of Orion, at the beginning [Quae ad sinistrum pedem Orionis in principio]	♐	9	40	21	35½	A	4
Above the foot of Orion, in the river [Supra pedem Orionis in fluvio]	♐	9	42	27	54½	A	3
The following of two others [Duarum aliarum sequens]	♐	7	39	25	52	A	5
The preceding [Praecedens]	♐	5	29 ½	27	51½	A	5
The following of the two upper ones [Sequens duarum superiorum]	♐	3	45 ½	25	34	A	4
The preceding of the same [Praecedens earundem]	♐	1	14	25	11½	A	4
Following at an interval, one of four [Post intervallum sequens ex quatuor]	♐	1	18 8	33	13½	A	3
The one that precedes this [Quae praeit hanc]	♐	1	22 5 ½	31	9	A	4
The one toward the north, or the third preceding [Quae ad septentrionem est, seu tertia praecedens]	♐	1	7 5	28	46½	A	3
The one preceding all four [Quae omnes quatuor antecedit]	♐	1	45 2	27	47	A	3

LEPVS [Lepus]

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The upper of the preceding ear [Superior praecedentis auris]	II	1 0	14 $\frac{1}{2}$	34	34	A	5
The lower of the same ear [Inferior ejusdem auris]	II	1 0	20 $\frac{1}{2}$	35	54	A	5
The upper of the following ear [Superior sequentis auris]	II	1 2	27	35	18	A	6
The lower of the following ear [Inferior sequentis auris]	II	1 2	14	36	14	A	5
The one in the head [Quae est in capite]	II	9	49	39	4	A	5
The outermost of the front feet [Extrema anteriorum pedum]	II	6 $\frac{1}{2}$	25	45	0	A	4
The one on the back, or middle of the body [Quae in dorso, seu medio corpore]	II	1 5	49 $\frac{1}{2}$	41	$5\frac{1}{2}$	A	3.
In the left shoulder [In armo sinistro]	II	1 4	$6\frac{1}{2}$	43	$57\frac{1}{2}$	A	3
The more southerly of two in the hind feet [Australior duarum in posterioribus pedibus]	II	1 9	21 $\frac{1}{2}$	45	$49\frac{1}{2}$	A	3.
The more northerly of the same [Borealior earundem]	II	2 1	36	44	18	A	3.
The preceding one on the back [Praecedens in dorso]	II	2 0	26 $\frac{1}{2}$	38	16	A	4
The following one on the back [Sequens in dorso]	II	2 3	27 $\frac{1}{2}$	37	$40\frac{1}{2}$	A	4
The last in the tail [Ultima in cauda] *	II	2 6	22	38	26	A	4.

CANIS MAIOR [Canis Major]

Description of the stars	S .	G .	M .	Lat. G.	Lat. M.	B./ A.	Magn.
The most brilliant one in the mouth, called Sirius [In ore splendidissima, Sirius vocata]	☾	8	35 $\frac{1}{2}$	39	30	A	1
The one on the forehead toward the right ear [Quae in fronte ad dextram aurem]	☾	1	1 $\frac{1}{2}$	34	50	A	4
In the middle of the forehead [In media fronte]	☾	1	27 1	36	43	A	5 [recte: magnitude printed as a triangular glyph, read as A/5?]
The one under the left ear [Quae sub sinistra aure]	☾	1	6 4	38	2 $\frac{1}{2}$	A	3.
In the neck [In collo]	☾	1	3 2	39	30	A	4
In the right shoulder of the front feet [In armo dextro anteriorum pedum]	☾	6	32 $\frac{1}{2}$	42	12 $\frac{1}{2}$	A	5
The one at the tip of the forward foot [Quae in extremitate pedis prioris]	☾	1	42 $\frac{1}{2}$	41	18 $\frac{1}{2}$	A	2.
The one on the back [Quae in dorso]	☾	1	30 5 $\frac{1}{2}$	46	9 $\frac{1}{2}$	A	5:
The middle one on the breast [Media in pectore]	☾	1	36 2 $\frac{1}{2}$	46	39 $\frac{1}{2}$	A	5:
The one on the belly [Quae in ventre]	☾	1	55 7	48	30	A	3.

Description of the stars	S	G	M	Lat. G.	Lat. M.	B./ A.	Magn.
On the belly between the hind thighs [In ventre inter posteriora femora]	♄	1	21 5 ½	51	24½	A	3
The lower of the right forward feet [Inferior dextri pedis priorum]	♄	1	7	51	46½	A	3
The one in the tail [Quae in cauda]	♄	2	11 4 ½	51	24½	A	3

CANIS MINOR [Canis Minor]

Description of the stars	S.	G	M.	Lat. G.	Lat. M.	B./A.	Mag n.
In the neck [In collo]	♄	1	39 6 ½	13	33½	A	3.
In the thigh, Procyon [In femore, Procyon]	♄	2	18 0 ½	15	57	A	2:

ARGVS [Argo]

Description of the stars	S.	G	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The one on the highest part of the stern [Quae in suprema puppi]	♄	5	53 ¾	43	18½	A	3
The highest of the ship's shield [Suprema clypei navis]	♄	0	35 ½	44	58½	A	3:
The preceding of the shield [Praecedens clypei]	♄	2	0 8	47	28	A	3

HYDRA

Description of the stars	S.	G	M.	Lat. G.	Lat. M.	B./A.	Mag n.
The preceding one in the head [Praecedens in capite]	♄	5	39 ½	14	37	A	5

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
Above the first, toward the north [Supra primam ad aquilonem]	♌	6	46	14	16½	A	4
The more northerly one in the back of the head [Borealiior in occipite]	♌	6	48	11	8	A	4
The one that precedes the third toward the south [Quae tertiam ad austrum praeit]	♌	7	22 ½	11	36	A	5
The most easterly of all in the head [Omnium in capite orientaliior]	♌	9	0½	11	1	A	4
The one preceding in the neck [Quae in collo praecedat]	♌	1	51 1 ½	11	5½	A	6
The following at the issuing of the neck [Sequens in eductione colli]	♌	1	41 4 ½	13	5	A	4
The middle of the neck, and preceding of three in the knot [Media colli, & praecedens trium in nexu]	♌	2	11 0 ½	15	0	A	5
The northern of three in the bend of the neck [Borea trium in flexu colli]	♌	2	4 2	14	17½	A	4
The southern one in the knot [Australis in nexu]	♌	1	53 9 ½	16	46	A	5
The bright star of Hydra, or the Heart [Lucida Hydrae, sive Cor]	♌	2	45 1 ½	22	24	A	1.
The one that follows nearest to the Heart [Quae proxime Cor sequitur]	♌	2	12 7	26	33½	A	4
The one that next follows this [Quae hanc deinde sequitur]	♍	0	9	26	12	A	5
The preceding of two adjacent	♍	2	48	23	13	A	5

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
above this [Praecedens ex duabus contiguus supra hanc]							
The following of the same [Sequens earundem]	♄	3	51	21	51	A	4
The one that is fifth from the Heart [Quae a corde quinta est]	♄	9	31 ½	24	38	A	4
The one in a straight line with this and the following [Quae in recta linea cum hac & sequente]	♄	1 2	41 ½	23	31	A	5
The one nearest preceding Crater [Cratera proxime praecedens]	♄	1 4	51	21	48½	A	4
Unformed, nearest preceding the head [Informis, caput proxime praecedens] *	♁	4	45 ½	12	27	A	4

CRATER

Description of the stars	S.	G		Lat. G.	Lat. M.	B./A.	Mag n.
		.	M.				
The one at the base of Crater [Quae est in basi Crateris]	♄	1 8	13	22	41	A	4
The following of two in the middle [Sequens duarum in medio]	♄	2 3	43	19	39	A	4
The preceding of the same [Praecedens earundem]	♄	2 1	10 ½	17	25	A	4

CORVVS [Corvus]

Description of the stars	S.	G M			Lat. G.	Lat. M.	B./A.	Mag n.
		.	.					
The one at the eye [Quae ad oculum]	♁	6	8		19	39	A	4
The preceding of two upper ones, in the square [Praecedens	♁	5	1 3		14	25	A	3

Description of the stars	S.	G M			Lat. G.	Lat. M.	B./A.	Mag n.
		.	.	.				
duarum superiorum in □]								
The following of the same [Sequens earundem]	♌	7	5	12		7	A	3
				5				
The following of the lower ones, in the square [Sequens inferiorum in quadrato]	♌	1	4	17		59	A	3.
		1	9					

TABVLA CONTINENS QVANTVM SINGVLI ANNI [Table showing how much each year, in the two preceding centuries, adds to the longitude of the fixed stars at the year 1600, arranged by the preceding canon]

The full heading: *Tabula continens quantum singuli anni, in duobus seculis antecedentibus, addant longitudini affixarum ad annum 1600, praecedenti canone dispositae.*

The table is laid out in four side-by-side blocks. Each block of "expanded years" (ANNI EXPANSI) gives, for a given year, the accumulated motion in degrees (G.), minutes (M.), and seconds (s.) to be added to or reckoned from the longitude at 1600. The leftmost three blocks run continuously from 1600 to 1700; the rightmost block holds the "collected years" (ANNI COLLECTI), the "single years" (ANNI SINGVLI), and the months (MENSES).

ANNI EXPANSI — years 1600–1632

Anni	M.	s.
1600	0	0
1601	0	51
1602	1	42
1603	2	33
1604	3	24
1605	4	15

Anni	M.	s.
1606	5	6
1607	5	57
1608	6	48
1609	7	39
1610	8	30
1611	9	21
1612	10	12
1613	11	3
1614	11	54
1615	12	45
1616	13	36
1617	14	27
1618	15	18
1619	16	9
1620	17	0
1621	17	51
1622	18	42
1623	19	33
1624	20	24
1625	21	15
1626	22	6
1627	22	57
1628	23	48
1629	24	39
1630	25	30
1631	26	21
1632	27	12

Years 1633–1666

Anni	M.	s.
1633	28	3

Anni	M.	s.
1634	28	54
1635	29	45
1636	30	36
1637	31	27
1638	32	18
1639	33	9
1640	34	0
1641	34	51
1642	35	42
1643	36	33
1644	37	24
1645	38	15
1646	39	6
1647	39	57
1648	40	48
1649	41	39
1650	42	30
1651	43	21
1652	44	12
1653	45	3
1654	45	54
1655	46	45
1656	47	36
1657	48	27
1658	49	18
1659	50	9
1660	51	0
1661	51	51
1662	52	42
1663	53	33
1664	54	24

Anni	M.	s.
1665	55	15
1666	56	6

Years 1667–1700

Anni	G.	M.	s.
1667	0	56	57
1668	0	57	48
1669	0	58	39
1670	0	59	30
1671	1	0	21
1672	1	1	12
1673	1	2	3
1674	1	2	54
1675	1	3	45
1676	1	4	36
1677	1	5	27
1678	1	6	18
1679	1	7	9
1680	1	8	0
1681	1	8	51
1682	1	9	42
1683	1	10	33
1684	1	11	24
1685	1	12	15
1686	1	13	6
1687	1	13	57
1688	1	14	48
1689	1	15	39
1690	1	16	30
1691	1	17	21
1692	1	18	12

Anni	G.	M.	s.
1693	1	19	3
1694	1	19	54
1695	1	20	45
1696	1	21	36
1697	1	22	27
1698	1	23	18
1699	1	24	9
1700	1	25	0

ANNI COLLECTI [Collected years]

Anni	G.	M.	s.
1700	1	25	0
1710	1	33	30
1720	1	42	0
1730	1	50	30
1740	1	59	0
1750	2	7	30
1760	2	16	0
1770	2	24	30
1780	2	33	0
1790	2	41	30
1800	2	50	0

ANNI SINGVLI [Single years]

Anni	G.	M.	s.
1	0	0	51
2	0	1	42
3	0	2	33
4	0	3	24
5	0	4	15
6	0	5	6
7	0	5	57

Anni	G.	M.	s.
8	0	6	48
9	0	7	39
10	0	8	30

MENSES [Months]

Month	s.	Month	s.
Ian. [January]	4	Iul. [July]	30
Feb. [February]	8	Aug. [August]	34
Mar. [March]	13	Septe. [September]	38
Apr. [April]	17	Octo. [October]	42
Mai. [May]	21	Nou. [November]	47
Iun. [June]	25	Dece. [December]	51

Instruction (printed beneath the months): Add the motion of the completed years to the longitude from the preceding table; (if you wish) add the months together with S. //. And so you will obtain what is sought. [*Anni compl. motū adde ad long. seq. Tab: Mensis unā (si uis) additis S. //. Sicq; petitum obtinebis.*]

[Margin: 373]

So now, most longed-for and welcome posterity, you have the restoration of the fixed stars — a restoration as accurate as it was possible to achieve, of very nearly all of them, and especially of the more important and noteworthy ones, as many as could be reached with any of our instruments not subject to the deceptions of error. It was carried through within the past decade or a little more, by the vigils of very many nights, by tireless labor of calculation, and at expense greater than any reckoning; at last it was brought to completion, fitted out for public use, and dedicated to you, who are eager for these things, as a free, generous, and lasting gift.

For so many ages now — about 1,700 years since that ancient Hipparchus [Hipparchus] — no one, so far as is known, has worked this out beforehand by a sound method directed to its proper goal. Ptolemy [Ptolemy], Hipparchus's successor, applied to the fixed stars only the precession that had accrued over the interval of time between himself and Hipparchus, taking into account a few other matters that he reserved for treatment elsewhere among all the Hipparchan reckonings. Albategnius [al-Battānī] did the same after him. That great corrector of the astronomical matters of an earlier age, Copernicus [Copernicus] too,

content with the Hipparchan and Ptolemaic description of the fixed stars, assigned the anticipation of the equinoxes to them in a certain universal manner — though he was surely not unaware that quite a few of them were found in a position that did not correspond exactly even to the sky itself, whether through the fault of the Ancients' insufficiently refined observation, or through the carelessness of copyists, or certainly through both causes together. Add to this that they thought it enough to measure each star's longitude and latitude from Hipparchus only to within a sixth of a degree — that is, by tens of minutes for each (one might wish, of course, that the goal thus set had been hit precisely enough). Whether such men judged greater precision in these matters superfluous, or whether this slenderness should rather be charged to the instruments they used, is open to question. Yet content with that coarse approximation in their numbering, all his successors down to our own day were too carelessly negligent, thinking it impossible to track down the subtle motions of the planets — which conform exactly to the heavens — without the precise and exquisite rectification of the fixed stars, especially of those which lie near the zodiac, along the planets' path.

Copernicus himself complained that he had no ready means sufficient for a solid restoration of astronomy, as Rheticus [Rheticus] records of him in a certain Preface. This task, then — long sought in vain both by Copernicus and by all others who have probed deeply into the inner recesses of astronomy, namely the precise determination, to the very minute, of the longitude as well as the latitude of the fixed stars — I am confident the practitioners of these arts will find neither useless nor unwelcome. And if any stars still remain visible above our horizon (which will indeed be very few, and not at all conspicuous to the eye), we have resolved to supply them all at the first opportunity, God the Maker of the heavens favoring us, and afterward to insert them in their entirety into the Theater of the Restoration of Astronomy on which we are at work. It must be noted, however, that where an obelisk

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has been prefixed in the foregoing Canonical exposition, those stars were not previously observed by the Ancients.

I think it should also be pointed out that Jacobus Florentius [Jacob Floris van Langren], a citizen of Amsterdam and a remarkable craftsman in the making of celestial and terrestrial globes, sending his son here — likewise skilled in that craft — has decided to fashion a certain celestial Globe, in accordance with this restoration of ours in the places of the fixed stars, one that will far surpass in

accuracy and skillful workmanship those in use up to now. I mention this so that, if any take pleasure in such things, they may all the more readily seek out this finished mechanical work, and so be the more promptly granted their wish.

Nor can I pass over in silence the most illustrious prince, Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel] — who in our age devoted tireless labor for more than thirty years to this lofty concern, praiseworthily, and at last achieved it: having, after my example, renewed some of his instruments, he attained the restoration of about four hundred fixed stars, as he indicated to me by letter that he had carefully accomplished. Yet in the longitudes of the fixed stars everywhere he holds, by his own reckoning, generally about five or six minutes more than my own annotation gives — as I gathered from a few stars he shared with me. On this matter, too, much has been exchanged between us by letters back and forth, as our volume of Astronomical Letters will more fully show. In the latitudes scarcely any discrepancy of moment is found between his findings and mine, except insofar as the unequal subtlety of prolonging the longitude and the declination on both sides may suggest some small difference in these. I also suppose that he did not guard against refraction in the lower-lying stars, and that this is the reason not only the longitude but, still more plainly, the latitude of these stars has been pushed downward a little. As for the fact that in the longitudes he extends the places of some stars onward by nearly an uncia [uncia] of one degree, this happens — we differ — because he undertook the emendation of the fixed stars through altitudes and azimuths together, at one and the same moment of time. That method is exceedingly slippery and exposed to error from various causes, as we indicated near the beginning of the second Chapter. For this reason I rather marvel that he reached such precision by this less-than-safe manner of observing — that so few scruples should be wanting here. And although he afterward took the boundaries of the fixed stars from the Sun by way of the planet Venus, with intermediate distances observed, in the manner familiar to us, and though warned of this he did not neglect it: even so he could not perceive that he had carried out their places a little too far by these very small scruples. For he attempted to test it through Venus only in her evening apparition, and not often enough; and there, because of refractions inclining toward the horizon both in the Sun and in Venus, the places of these bodies are prolonged farther in consequence than is right, and thereby the longitudes of the fixed stars

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built upon them turn out somewhat too large. But if he had set up this procedure with equal exactness on the morning Venus, he would surely have clearly grasped that, owing to the impediments of refraction, he had advanced their places a little too far — just as we have demonstrated by manifold experiment in the second Chapter. So that, on this account, I do not hesitate to interpose my firm assurance that scarcely a single minute in our stellar longitudes lies astray, on this side or beyond — let alone that the same stars should be anticipated by fives or sixes, as the Landgrave's opinion holds.

Nonetheless, the study of that excellent prince is worthy of everlasting praise, in that with so arduous an effort, and with such great diligence, he bore the burden of carrying through the emendation of the fixed stars — so that in those few minutes (in which scarcely any perceptible wandering can occur) there is almost no significance, nor has even so much precision been reached by any of the ancient astronomers. As soon as the work of his Highness on this restoration of the fixed stars has appeared in public — as he long ago gave us hope it would — it will then at last be readier to bring to light the occasions of this small discrepancy between us; and how diligently the places of the fixed stars have been restored anew by both parties will be evident beyond all doubt, once a comparison of the two sets of observations has been instituted: a comparison no less pleasant than useful, since they were carried out in different places, and neither set was disclosed to the other from the start. It would therefore be desirable that this distinguished labor be made public in good time, to the perpetual celebration of the Landgrave's name; and that those eager for it not be too long frustrated of their desire.

Moreover, a preceding and a following Table will readily show how much each single year, in the two preceding or following centuries, adds to or takes from the longitude of the stars here recorded. The latitudes, although not altogether invariable — as is generally believed up to now, but permanent — have been found by us liable to no change deriving from the inclination of the ecliptic. And since this admits of perceptible alteration only very slowly, the departures of the stars in latitude from the Sun's orbit will scarcely undergo any perceptible variation within three or four centuries.

Finally, just as we have elaborately set out the places of very many of the fixed stars with respect to the ecliptic, so too we judged that this same thing should not be left undone with respect to the equator, for some hundred selected stars.

Therefore, in the following Canon, we have adapted the right ascensions and declinations of the same number of stars, computed for the completed years 1600

and 1700, with the intervening difference set alongside as well, so that for the intermediate years too they may be applied proportionally.

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A TABLE CONTAINING THE RIGHT ASCENSIONS AND DECLINATIONS OF ONE HUNDRED SELECTED STARS

For the completed years 1600 and 1700. Together with the difference intervening between them.

	160	160	160	160					170	170	170	170
	0	0	0	0	B	Diff.	Diff.	Diff.	0	0	0	0
Names of	R.A.	R.A.	Dec	Dec	/	R.A.	R.A.	Decl	R.A.	R.A.	Dec	Dec
the Stars	. G.	. M.	l. G.	l. M.	A	G.	M.	. M.	. G.	. M.	l. G.	l. M.
Schedir Cassiope ae [Schedar, α Cas]	4	36	54	21	B	1	22	34	5	58	54	55
Stella Polaris [the Pole Star, α UMi]	5	47	87	9½	B	3	59	34	9	46	87	43½
Australis cauda Cete [souther n tail of Cetus]	5	51	20	12	A	1	17	34	7	8	19	38
Flexura Cassiope ae [bend of Cassiopei a]	8	21	58	33	B	1	27	34	9	48	59	7
Cingulū Androme	11	50	33	32	B	1	23	33	13	13	34	5

	160	160	160	160					170	170	170	170
	0	0	0	0	B	Diff.	Diff.	Diff.	0	0	0	0
Names of	R.A	R.A	Dec	Dec	/	R.A.	R.A.	Decl	R.A	R.A	Dec	Dec
the Stars	. G.	. M.	l. G.	l. M.	A	G.	M.	. M.	. G.	. M.	l. G.	l. M.
dae												
[girdle of Andromeda]												
Genu Cassiopeae [knee of Cassiopeia]	15	3	58	7	B 1	35	33		16	38	58	40
Praecedens cornu γ [preceding horn of Aries]	22	56	17	19	B 1	23	31		24	19	17	50
Venter Cete [belly of Cetus]	22	59	12	16	A 1	15	31		24	14	11	45
Sequens cornu γ [following horn of Aries]	23	10	18	50	B 1	22	31		24	32	19	21
Australis pes Androm. [southern foot of Andromeda]	24	55	40	23	B 1	29	30		26	24	4	53
Nodus lini *	25	22	0	50	B 1	18	30		26	40	1	20

	160	160	160	160					170	170	170	170
	0	0	0	0	B	Diff.	Diff.	Diff.	0	0	0	0
Names of	R.A	R.A	Dec	Dec	/	R.A.	R.A.	Decl	R.A	R.A	Dec	Dec
the Stars	. G.	. M.	l. G.	l. M.	A	G.	M.	. M.	. G.	. M.	l. G.	l. M.
[knot of the flaxen thread, in Pisces]												
Lucida Υ [the bright star of Aries]	26	13	21	33	B	1	25	30	27	38	22	3
Lucida mādibul ae Cete [bright star of the jaw of Cetus]	40	25	2	29	B	1	15	25	41	40	2	54
Caput Medusae [head of Medusa]	40	38	39	22	B	1	37	25	42	15	39	47
Lucidum latus Persei [bright flank of Perseus]	44	2	48	22	B	1	28	21	45	30	48	43
Lucida Pleiadum γ [the bright star of the Pleiades,	50	57	22	49	B	1	29	21	52	26	23	10

	160	160	160	160					170	170	170	170
	0	0	0	0	B	Diff.	Diff.	Diff.	0	0	0	0
Names of	R.A	R.A	Dec	Dec	/	R.A.	R.A.	Decl	R.A	R.A	Dec	Dec
the Stars	. G.	. M.	l. G.	l. M.	A	G.	M.	. M.	. G.	. M.	l. G.	l. M.
in Taurus]												
Infima	59	16	14	37	B	1	25	17	60	41	14	54
Hyadum												
♄												
[lowest												
of the												
Hyades,												
in												
Taurus]												
Boreus	61	21	18	14	B	1	24	17	62	45	18	31
oculus ♄												
[the												
northern												
eye, in												
Taurus]												
Aldebara	63	16	15	38	B	1	26½	15	64	43	15	52
n ♄		½										
[Aldebar												
an, α												
Tau]												

Book I, Chapter II (continued)

Table of the right ascensions and declinations of one hundred selected stars (continued)

The table continues from the preceding pages. As before, each star is given its right ascension (Asc. recta) and declination (Declinatio) for the year 1600 and for the year 1700, in degrees (G.) and minutes (M.), together with the intervening difference (Differentia) in right ascension and in declination. In the declination columns the marker **B.** (*Borealis*, northern) or **A.** (*Australis*, southern) indicates the hemisphere; in the difference columns **A** marks an additive change and **S** (*subtractive*) a diminishing one. All numerals are transcribed verbatim as printed.

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Capella	71	49	45	30	B	1	49	10	73	38	45	40
Lucid ⁹ pes	73	51	8	43	A	1	15	9½	75	7	8	33½
Orio.		½					½					
Regel												
[Rigel, the												
bright												
foot of												
Orion]												
Boreale	75	16	28	12	B	1	37	8	76	53	28	20
cornu ♂												
[northern												
horn of												
Taurus]												
Preced.	75	58	5	55	B	1	19	8	77	17	6	3
humerus												
Orio.												
[precedin												
g												
shoulder												
of Orion]												
Femur	77	48	21	6	A	1	5	7	78	53	20	59
Leporis												
[thigh of												
Lepus]												
Precedens	77	58	0	39	A	1	17	7	79	15	0	32
baltei												
Orio.												
[precedin												
g star of												
Orion's												
belt]												
Suprema	78	21	9	36	B	1	22	7	79	43	9	43

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
capitis Orio. [topmost star of Orion's head]												
Aurolale cornu Ÿ [southern horn of Taurus]	78	26	20	51	B	1	31	7	79	57	20	58
Media baltei Orionis [middle star of Orion's belt]	79	1	1	30	A	1	17	6	80	18	1	24
Inferior baltei Orionis [lower star of Orion's belt]	80	10	2	12	A	1	16	5	81	26	2	7
Dexter humer ⁹ Aurigæ [right shoulder of Auriga]	82	40	44	50	B	1	55	4	84	35	44	54
Sequens humer ⁹	83	26	7	16	B	1	22	4	84	48	7	20

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Orio. [following shoulder of Orion]												
Lucidus pes II [bright foot of Gemini]	93	38	16	40	B	1	28	2	95	6	16	38
Canis maior. Sirius [Sirius]	96	53	16	11	A	1	7	4	98	0	16	15
Superius caput II [upper head of Gemini]	10 7	9	32	41	B	1	44	11	10 8	53	32	30
Canis minor. Procyon [Procyon]	10 9	37	6	12	B	1	20	12	11 0	57	6	0
Inferius caput II [lower head of Gemini]	11 0	13	28	55	B	1	34	12	11 1	47	28	43
Lucida in puppi Nauis [bright star in the	11 7	39	23	11	A	1	4	15	11 8	43	23	26

	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
Star name	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
stern of Argo Navis]												
Præsepe ♊ [Praesepe in Cancer]	12 4	20	21	2	B	1	28	19	12 5	48	20	43
Boreus asellus ♊ [northern Aselli in Cancer]	12 4	58	22	51	B	1	30	20	12 6	28	22	31
Australis asellus ♊ [southern Aselli in Cancer]	12 5	27	19	35	B	1	27	20	12 6	54	19	15
Cor Hydræ [heart of Hydra, Alphard]	13 7	1	6	57	A	1	15	25	13 8	16	7	22
Infima ceruicis ♌ [lowest star of the neck of Leo]	14 6	22	18	42	B	1	28	28	14 7	50	18	14
Cor ♌, Basiliscus [heart of Leo, Regulus]	14 6	45 ½	13	53½	B	1	22 ½	28½	14 8	8	13	25

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Suprema ceruicis ϱ [topmost star of the neck of Leo]	14 8	33	25	23	B	1	28	29	15 0	1	24	54
Media ceruicis ϱ [middle star of the neck of Leo]	14 9	25 $\frac{1}{2}$	21	50	B	1	25 $\frac{1}{2}$	29	15 0	51	21	21
Infer. $\bar{\rho}$ ced. $\square$ Vrsæ mai. [lower preceding star of the square of Ursa Major]	15 9	12	58	31	B	1	37	32	16 0	49	57	59

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Superior $\square$, Dubhe [upper star of the square,	15 9	37	63	54	B	1	41	32	16 1	18	63	22

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Dubhe]												
Lucida lumbi ϱ [bright star of the loins of Leo]	16 3	10	22	43	B	1	27	34	16 4	37	22	9
Cauda ϱ [tail of Leo, Denebola]	17 2	9	16	49	B	1	19	34	17 3	28	16	5
Infer. seq. $\square$ Vrsæ mai. [lower following star of the square of Ursa Major]	17 3	3	55	57	B	1	23	34	17 4	26	55	23
Superior $\square$ sequent. [upper following star of the square]	17 8	50	59	15	B	1	20	34	18 0	10	58	41
Cingulum $\mathfrak{M}$ [girdle of Virgo]	18 8	53	5	37	B	1	18	34	19 0	11	5	3
Radix caudæ	18 9	1	58	10	B	1	9	33	19 0	10	57	37

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Vrsæ ma. [root of the tail of Ursa Major]												
Vindemia trix Ṁ [Vindemi atrix in Virgo]	19 0	36	13	8	B 1		17	33	19 1	53	12	35
Spica Ṁ [Spica]	19 6	4	9	1	A 1		19 ½	32½	19 7	23 ½	9	33½
Penul. caudæ Vrse ma. [penultim ate star of the tail of Ursa Major]	19 6	54	57	3	B 1		3	32	19 7	57	56	31
Vltima caudæ eiusdem [last star of the same tail]	20 2	54	51	22	B 1		2	31	20 3	56	50	51
Arcturus	20 9	23 ½	21	18½	B 1		11	29½	21 0	34 ½	20	49
Sinister humer ⁹ Bootæ [left	21 4	2	40	3	B 1		2	27	21 5	4	39	36

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
shoulder of Boötes]												
Austrina lanx $\simeq$ [southern pan of Libra]	21 7	14 $\frac{1}{2}$	14	18	A	1	23	27	21 8	37 $\frac{1}{2}$	14	45
Borea lanx $\simeq$ [northern pan of Libra]	22 3	54 $\frac{1}{2}$	7	50	A	1	21 $\frac{1}{2}$	24	22 5	16	8	14
Coronæ Lucida [bright star of Corona Borealis]	22 9	26	28	6	B	1	5	21	23 0	31	27	45
Lucida colli Serpentis [bright star of the neck of Serpens]	23 1	12	7	46	B	1	15	21	23 2	27	7	25
Borealis frontis $\mathfrak{M}$ [northern star of the forehead, in Virgo]	23 5	34	18	38	A	1	28	19	23 7	2	18	57
Sinistr.	23	25	2	37	A	1	23	18	23	48	2	55

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
man ⁹	8								9			
Ophiuchi												
[left hand												
of												
Ophiuchu												
s]												
Cor M,	24	18	25	26	A	1	32	16	24	50	25	42
Antares	1								2			
[heart of												
Scorpius,												
Antares]												
Dexter	24	15	22	27	B	1	5	15	24	20	22	12
hum.	3								4			
Herculis												
[right												
shoulder												
of												
Hercules]												
Sinistr.	24	49	9	39	A	1	23	15	24	12	9	54
genu	3								5			
Ophiuchi												
[left knee												
of												
Ophiuchu												
s]												
Dextr.	25	50	15	7	A	0	50	10	25	40	15	17
genu	1								2			
Ophiuchi												
[right												
knee of												
Ophiuchu												
s]												
Caput	25	6	14	55	B	1	8	8	25	14	14	47

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Herculis [head of Hercules]	4								5			
Sinister hum. Herculis [left shoulder of Hercules]	25 4	40	25	22	B	0	52	8	25 5	32	25	14
Caput Ophiuchi [head of Ophiuchus]	25 9	5	12	56	B	1	11	7	26 0	16	12	49
Dexter hum. Ophiuchi [right shoulder of Ophiuchus]	26 0	56	4	49	B	1	13	5	26 2	9	4	44

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Lucida capi. Draconis	26 6	52	51	37	B	0	35	2	26 7	27	51	35

	RA	RA	Decl	Decl	B .	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
Star name	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
[bright star of the head of Draco]												
Lucida Lyræ [bright star of Lyra, Vega]	27 5	52	38	28	B 0		50	4	27 6	42	38	32
Orientalis capitis ♂ [eastern star of the head of Sagittarius]	28 1	32	21	35	A 1		31	8	28 3	3	21	27
Cauda Vulturis [tail of Aquila]	28 1	47	13	20	B 1		13	8	28 3	0	13	28
Rostrum Cygni [beak of Cygnus, Albireo]	28 8	40	27	10	B 1		1	11	28 9	41	27	21
Lucida Vulturis [bright star of Aquila, Altair]	29 2	49	7	54	B 1		17	13	29 4	6	8	7

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Superior ala Cygni [upper wing of Cygnus]	29 3	10	44	12	B	0	48	14	29 3	58	44	26
Superius cornu ♄ [upper horn of Capricorn us]	29 8	57	13	40	A	1	25	16	30 0	22	13	24
Inferius cornu ♄ [lower horn of Capricorn us]	29 9	39	15	57	A	1	27	17	30 1	6	15	40
Pectus Cygni [breast of Cygnus, Sadr]	30 2	1½	39	1	B	0	53 ½	18	30 2	55	39	19
Sinistra manus ♁ [left hand of Aquarius]	30 6	32	10	53	A	1	16	19	30 7	48	10	34
Cauda Cygni [tail of Cygnus, Deneb]	30 6	57 ½	43	53½	B	0	51 ½	20½	30 7	49	44	14
Inferior	30	31	32	30	B	1	0	21	30	31	32	51

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
ala Cygni	7								8			
[lower wing of Cygnus]												
Sinister humerus	31	37	7	15	A	1	21	26	31	58	6	49
♁ [left shoulder of Aquarius]	7								8			
Præcedens cauda ♄	31	28	18	21	A	1	26	26	32	54	17	55
[preceding star of the tail of Capricornus]	9								0			
Cingulum Cephei	32	46	68	50	B	0	22	26	32	8	69	16
[girdle of Cepheus]	0								1			
Os Pegasi	32	10	8	5	B	1	18	26	32	28	8	31
[mouth of Pegasus, Enif]	1								2			
Sequens cauda ♄	32	16	17	51	A	1	25	27	32	41	17	24
[following star of the tail of Capricornus]	1								2			

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Dexter humerus ♁ [right shoulder of Aquarius]	32 6	19	2	13	A	1	20	29	32 7	39	1	44
Fomahant ♁ [Fomalha ut]	33 8	46	31	39	A	1	25	31	34 0	11	31	8
Scheat Pegasi [Scheat]	34 1	9	25	56	B	1	12	32	34 2	21	26	28
Marchab Pegasi [Markab]	34 1	15	13	5	B	1	15	32	34 2	30	13	37
Occiput ✕ australis [southern back-of- the-head star, in Pisces]	34 4	9	1	7	B	1	17	33	34 5	26	1	40
Caput Androme dæ [head of Androme da, Alpheratz]	35 6	59	26	54	B	1	17	34	35 8	16	27	28
Lucida cathedrę	35 7	5	56	58	B	1	15	34	35 8	20	57	32

Star name	B											
	RA	RA	Decl	Decl	.	Diff	Diff		RA	RA	Decl	Decl
	16	16	.	.	/	.	.	Diff.	17	17	.	.
	00	00	1600	1600	A	RA	RA	Decl.	00	00	1700	1700
	G.	M.	G.	M.	.	G.	M.	M.	G.	M.	G.	M.
Cass. [bright star of the throne of Cassiopei a]												
Extrema alæ Pegasi [outermos t star of the wing of Pegasus, Algenib]	35 8	14	12	58	B	1	16	34	35 9	30	13	32
Borealis cauda Cete [northern star of the tail of Cetus, Deneb Kaitos]	35 9	49	11	1	A	1	18	34	1	7	10	27

DE REFRACTIONIBVS STELLARVM [On the refraction of the stars]

Table of the refraction of the fixed stars [Tabula Refractionum Fixarum Stellarum]

The table gives, for each degree of altitude (Alt.) from 0 to 20, the refraction (Refra.) in minutes (M.) and seconds (s.).

Altitude (G.)	Refraction M.	Refraction s.
0	30	0
1	21	30
2	15	30
3	12	30
4	11	0
5	10	0
6	9	0
7	8	15
8	6	45
9	6	0
10	5	30
11	5	0
12	4	30
13	4	0
14	3	30
15	3	0
16	2	30
17	2	0
18	1	15
19	0	30
20	0	0

Just as above, in Chapter 1, the Sun's refractions are presented as they occur in the vertical circle — that is, the refractions caused by the vapors that surround the Earth even now, since the air, being far from perfectly transparent, makes the heavenly bodies, when they are in a lower position, appear somewhat higher to the eye than they really are. In the same way, this hindrance of refraction insinuates itself, not obscurely, into the stars themselves, both fixed and wandering, and must not be passed over. I therefore judged it worth the effort to take account of this refraction in the stars as well. If it is neglected, an observation in keeping with the heaven itself cannot be made — especially when the stars approach nearer to the horizon — nor can anything certain be derived from it concerning the apparent positions of the planets.

By comparing a good many observations of preceding years on this point, I have found the refractions seen in the stars to be smaller by about $4\frac{1}{2}$ minutes than those that occur at very nearly the same altitude in the case of the Sun — so much so that by 20 degrees of altitude, where the Sun still shows that many minutes of refraction, in the stars this becomes plainly imperceptible to the eye, vanishing through the intervening vapors, and presents no notable obstacle in any higher position. I have therefore drawn up the accompanying little table in such a way that, at any given degree of altitude, its refractions fall short by the $4\frac{1}{2}$ minutes from those I noted above in the case of the Sun.

I judge, moreover, that these same refractions of the fixed stars may not unsuitably be applied to the planets as well, since the difference is scarcely perceptible — except perhaps that the Moon, in the cases I set out concerning its position near the Sun, may be liable to somewhat larger refractions on account of its nearness. As for the rest, which there are subject to the refractions, I have indicated — according to the variation in the purity and condition of the air and horizon — that they must here likewise be understood. And if what the Landgrave's Mathematician noted on these matters at Cassel is correct, the stellar refractions admitted there are about double those here. On this question fuller information is given in the *Volume of Letters*, where I set out our comparisons. Yet I would nonetheless believe that, through some carelessness of observation, the refraction itself was there made too small, and that in reality so great a difference does not arise as against my own determination.

Furthermore, as to how these refractions are to be distributed with respect to the equator and the ecliptic — since this was shown sufficiently and demonstratively in the aforesaid chapter on the Sun, and since the matter has a wholly similar place here too — I consider it superfluous to repeat it now.

This, then, on the fixed stars: it should suffice to have set out here the positions of so many of them — both in ecliptic terms (longitude and latitude), for the great majority, and, for a good number, in equatorial terms (right ascension and declination). Their refractions too, which bear on the more reliable examination of observations, have not been omitted.

As for the method of deriving right ascensions and declinations from given stellar longitudes and latitudes, I will explain it elsewhere in this work, in some of the following chapters, when the matter calls for it; and since the operation is in any case not difficult, and has already been treated quite thoroughly by others as well, I do not wish to dwell on expounding it here. Anyone who wishes to may, for a chosen epoch, test these stars — or others, and more of them — against the

equator by such reasoning, working analogously, and reduce them to numbers. Doing so will perhaps be still more exact than if one were to use our figures proportionally for the requirements of the intervening years, by interpolating between the two supposed centuries [1600 and 1700], whether close to the preceding one or to the following. For that proportional method does not hit the mark to the last degree everywhere — though the discrepancy that arises is not so very great.

Some also take into account the degrees and minutes of the ecliptic that correspond to these right ascensions as they meet on the meridian circle, so that it may be established with what point of the ecliptic a given star crosses the meridian. They judge this to contribute something to the planets — which coincide with these points — once the relation has been made, and to meteorological and genethliacal [astrological-natal] predictions. So that their wishes too may be satisfied, it will not be difficult, from our table of right ascensions (which I drew up in the first chapter, on the obliquity of the ecliptic at its maximum, with careful adaptation) to investigate that very thing. The right ascension in question, if it is sought within the area of the said table, will at once, in the heading above and as one descends along the side, reveal the place of the ecliptic that corresponds to it. Since these matters are easy in themselves, I have not judged it worth the trouble to enter the point of culmination, corresponding to the stars' right ascensions, in the table above.

Furthermore, if anyone wishes to know the oblique ascensions and descensions of particular fixed stars for any given horizon, together with the places of the ecliptic that answer to them, this can be accomplished without difficulty from the right ascensions and declinations given in the manner described — provided he brings to bear the reasoning of spherical triangles, which has been sufficiently and amply explained elsewhere by others. To fill many pages here on that subject would be far too long; perhaps elsewhere there will be an opportunity to set out these and similar things more particularly and to reduce them to tables. Whoever wishes may follow in others' footsteps in these matters, even though it may be possible to attain them by a more compendious inquiry.

The further things that might be set out about the fixed stars for some special utility, both in general and in particular, our whole work of

— the restoration of astronomy will supply in its own time, more fully and more generously, if it shall so please the Divine Power; meanwhile, let those eager for these matters take this in good part. We will now pass on to setting out the stars of Cassiopeia individually and separately, since the phenomena of the New Star

— which is what we have chiefly proposed to explain in this book — are particularly served by their being unfolded one by one.

[Margin: 6] On the Stars of Cassiopeia, to be arranged, by particular demonstration from certain Observations, for the completed Year 1572.

Since in this prior volume on that New Star which first shone forth toward Cassiopeia in the Year 1572, and afterward disappeared, we have undertaken to treat the matter expressly, and since the observation of the stars of Cassiopeia and a just record of them is required for this purpose, I therefore think I shall be doing nothing beside the point if I set out, from certain Observations, the places of all of them — twenty-six in number (twice as many as Antiquity counted) — demonstrated by the method of spherical triangles. This is, in part, so that it may be established that I have derived their celestial positions not arbitrarily but with great care and subtlety; and in part so that some Examples may be ready to hand, showing how the places of the fixed stars are likewise to be thoroughly investigated by Distances from two other [stars]. For in those stars which lie toward each of the Poles, this method is subject to a surer practice than that other reasoning by which we elsewhere proceeded, by way of Declinations and Distances, in the foregoing. Indeed, for stars occupying the region of the sky midway between either Pole, that [other method] deserves the foremost place.

I shall therefore first set down the Longitudes and Latitudes of four principal Stars, completed for the Year [15]72, from which I have derived the positions of all those situated in Cassiopeia, by Observation and Demonstration. And this I shall present to the eyes by that method of Calculation which I will indicate as briefly as possible — judging that, for the intelligent, enough will have been said; the rest I leave to be learned thoroughly and unfolded by their own diligence.

A Table containing the places of four notable Stars, from which we have derived the stars of Cassiopeia, by the observed Distances, by the following method.

Names of the Stars	Longitude (deg.)	Longitude (min.)	[Sign]	Latitude (deg.)	Latitude (min.)	[N/S]
Lucida γ [the bright star of Aries]	1	41½	γ	9	57	N
Aldebaran	5	48½	Π	5	30½	S

Names of the Stars	Longitude (deg.)	Longitude (min.)	[Sign]	Latitude (deg.)	Latitude (min.)	[N/S]
Inferius caput Π [the lower head of Gemini]	17	19	$\mathfrak{S}$	6	38	S
Capella	15	52½	Π	22	50½	N

The Little Star in the Head of Cassiopeia.

About to unfold by demonstration the position of this first star in Cassiopeia, I shall set forth briefly the connections of the triangles and the Method of derivation, so that — for the greater part — the same may be applied to what follows, for the sake of clearer understanding, and there be no need of tedious repetition in each individual case.

I measured the Distance of this star from Lucida [Arietis], above the Head of Aries, as $34^{\circ}34' 47\frac{1}{2}''$; and from Capella as $43^{\circ}43' 44\frac{1}{2}''$. Hence I shall investigate its place by the following reasoning. Let, in the assigned diagram, P be the Pole of the Ecliptic, A Capella, B the bright star of Aries [Lucida Arietis], C the Head of Cassiopeia, whose place we have set out to determine.

Diagram. A spherical triangle inscribed within a quadrant-like curvilinear figure. The apex at top is labelled P (the Pole of the Ecliptic); from it, arcs descend to the lower vertices. The figure shows the spherical triangles P–A–B and the related constructions used to derive the position of the Head of Cassiopeia.

- P (apex, top): the Pole of the Ecliptic
- A (lower left): Capella
- B (lower middle/right): Lucida Arietis (the bright star of Aries)
- C (upper interior, between P and B): the Head of Cassiopeia
- D (bottom left): base-point of the arc through A
- E (bottom, near center): base-point
- F (bottom, near E): base-point

First, then, in Triangle A P B: since two sides are given — A P, the complement of Capella's Latitude, $67^{\circ}67' 9\frac{1}{2}'$; P B, the Complement of the Latitude of the bright star of Aries, $80^{\circ}80' 3'$ — and the Angle intercepted at A P B, given through the difference of the Longitudes of the two Stars, $44^{\circ}44' 11'$, the third side A B will be found, by the laws of Triangles, to be $44^{\circ}44' 6' 35''$. This represents the distance

between Lucida Arietis and Capella; and it agrees to the last degree with the distance we have several times observed instrumentally. From these now-given three sides of the same Triangle, the Angle P A B cannot fail to follow; it comes out by the operation to be $99^{\circ}99'30''17''$.

Next, in Triangle B A C: since the side A C is known from the interval between Capella and the Head of Cassiopeia, as I said, $43^{\circ}43'44\frac{1}{2}'$; and B C, from the distance of Lucida Arietis and the same Head of Cassiopeia, $34^{\circ}34'47\frac{1}{2}'$; while B A, moreover, represents the interval between Capella and Lucida Arietis, $44^{\circ}44'6'35''$ — therefore, from the three known Sides, the Angle B A C will be made manifest, $51^{\circ}51'3'15''$. With this taken away from the Angle P A B found above, the remaining Angle will be P A C, $48^{\circ}48'27'$.

Finally, in Triangle P A C: since P A is known through the Complement of Capella's Latitude, $67^{\circ}67'9\frac{1}{2}'$; C A from the observed distance of Capella and the Head of Cassiopeia, $43^{\circ}43'44\frac{1}{2}'$; and the Angle P A C included between them has just now become clear, $48^{\circ}48'27'$ — the Third Side P C cannot be wanting: $45^{\circ}45'19\frac{1}{2}'$, exhibiting the complement of the Latitude of the Head of Cassiopeia. And so, from the three now-known Sides in the same Triangle, the Angle A P C as well will come into the open, $46^{\circ}46'41\frac{1}{2}'$, supplying the difference of Longitude of the proposed Star of Cassiopeia. This, subtracted from the Longitude of Capella (with which we are dealing), will at last lay open the sought Longitude: $29^{\circ}29'11'$ of Aries. With the Latitude, found earlier from the Complement, agreeing at $44^{\circ}44'40\frac{1}{2}'$ North — which is what we proposed to discover by demonstration.

By a like Method we have thoroughly investigated the remaining Stars of Cassiopeia, which (this introduction being premised) we will now review by a concise indication. Wherever some variation may have crept in, the intelligent will easily discern it.

There Follow the Demonstrations of the Places of the Twenty-Six Stars of Cassiopeia.

This page presents the demonstrations in two parallel columns, each headed by a numbered star with its observed distances, a spherical-triangle diagram, and the computed triangle data leading to the derived Longitude and Latitude.

I. Head of Cassiopeia [I. CAPVT CASSIOPEÆ]

Between this and Lucida Υ [Lucida Arietis]: $34^{\circ}34'47\frac{1}{2}'$ (G. M.) Between the same and Capella: $43^{\circ}43'44\frac{1}{2}'$

Diagram. A spherical triangle within a quadrant-like curvilinear figure, apex P at top.

- P (apex, top): Pole of the Ecliptic [Polus Eclipticæ]
- A (left): Capella
- B (lower right): Lucida Υ [Lucida Arietis, the bright star of Aries]
- C (interior, right of center): Head of Cassiopeia [Caput Cassiopeæ]
- D (bottom left): base-point
- E (bottom center): base-point
- F (bottom, near E): base-point

I. Triangle A P B (G. M. S.)

		deg.	min.	sec.
Side	P A	67	9	30
Side	P B	80	3	0
Angle	A P B	44	11	0
Side	B A	44	6	35
Angle	P A B	99	30	17

II. Triangle B A C

		deg.	min.	sec.
Side	A C	43	44	30
Side	B C	34	47	30
Side	B A	44	6	35
Angle	B A C	51	3	15

III. Triangle P A C

		deg.	min.	sec.
Side	P A	67	9	30
Side	C A	43	44	30
Angle	P A C	48	27	0
Side	P C	45	19	30
Angle	A P C	46	41	30

Therefore, of the Head of Cassiopeia:

	Sign	deg.	min.	sec.
Longitude	♈ [Aries]	29	11	0
Latitude	N [Borealis]	44	40	30

II. Schedir [II. SCHEDIR]

Between this and Lucida ♈ [Lucida Arietis]: $36^{\circ}36'38\frac{1}{3}'$ (G. M.) Between the same and the lower [head of Gemini], Cap. ♊ [inferius Caput Geminorum]: $75^{\circ}75'11\frac{1}{4}'$

Diagram. A spherical triangle within a quadrant-like curvilinear figure, apex P at top.

- P (apex, top): Pole of the Ecliptic [Polus Eclipticæ]
- A (right): Lucida ♈ [Lucida Arietis]
- B (left): the lower head of Gemini [Inferius caput ♊]
- C (interior, near center): Schedir of Cassiopeia [Schedir Cassiopeæ]
- F (bottom left): base-point
- E (bottom center): base-point
- D (bottom, right of E): base-point

I. Triangle B P A (G. M. S.)

		deg.	min.	sec.
Side	B P	83	22	0
Side	A P	80	3	0
Angle	B P A	75	37	0
Side	B A	74	45	8
Angle	P B A	81	27	15

II. Triangle A B C

		deg.	min.	sec.
Side	B C	75	11	15
Side	A C	36	38	20
Side	A B	74	45	8
Angle	C B A	37	58	58

III. Triangle P B C

		deg.	min.	sec.
Side	P B	83	22	0
Side	B C	75	11	15
Angle	P B C	43	28	17
Side	P C	43	24	42
Angle	B P C	75	25	43

Therefore, of Schedir:

	Sign	deg.	min.	sec.
Longitude	♈ [Taurus]	1	53	17
Latitude	N [Borealis]	46	35	20

Demonstrations of the Positions of the 26 Stars of Cassiopeia (continued)

The framed two-column per-star demonstrations of the positions of the stars of Cassiopeia continue (stars III through X of the 26). Each entry gives: the two reference-arcs measured to the star, a small spherical-triangle diagram with its lettered labels, three triangle solutions, and the resulting longitude and latitude.

Stars III and IIII

III. CINGULUM [The Girdle of Cassiopeia]

	G.	M.
Between this star and Lucida Arietis [Lucida ♈]:	37	12
Between the same and Capella:	41	7¾

Diagram. A spherical triangle with apex P at top, the curved sides descending to A (left) and B (right), with C as an interior point and an arc through C; below, a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: Lucida Arietis [Lucida ♈]
- C: Girdle of Cassiopeia [Cingulum Cassiopeae]

I. Triangle P A B.

		G.	M.	S.
Side	PB	80	3	0
Side	PA	67	9	30
Angle	APB	44	11	0
Side	BA	44	6	40
Angle	PAB	99	30	17

II. Triangle B A C.

		G.	M.	S.
Side	BA	44	6	40
Side	CA	41	7	45
Side	BC	37	12	0
Angle	BAC	56	2	42

III. Triangle P A C.

		G.	M.	S.
Side	PA	67	9	30
Side	CA	41	7	45
Angle	PAC	43	27	35
Side	PC	42	54	45
Angle	APC	41	38	30

Therefore, of the Girdle:

		G.	M.	S.
Longitude	♈ [Taurus]	4	14	0
Latitude	B. [North]	47	5	15

IIII. FLEXURA [The Bend (of Cassiopeia)]

		G.	M.
Between this star and Lucida Arietis [Lucida ♈]:		39	10¾
Between the same and the lower [star] of the Head of Gemini [inf. Cap. ♊]:		71	25

Diagram. A spherical triangle with apex P at top, sides descending to B (left) and A (right), interior point C, and a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Lucida Arietis [Lucida ♈]
- B: Lower [star of the] Head of Gemini [Caput inferius ♊]
- C: The Bend [Flexura]

I. Triangle P A B.

		G.	M.	S.
Side	PA	80	3	0
Side	PB	83	22	0
Angle	APB	75	37	0
Side	BA	74	45	10
Angle	PBA	81	27	15

II. Triangle B A C.

		G.	M.	S.
Side	CA	39	10	45
Side	BC	71	25	0
Side	BA	74	45	10
Angle	CBA	40	53	12

III. Triangle B P C.

		G.	M.	S.
Side	BF	83	22	0 [recte: BP — see Parsing notes]
Side	BC	71	25	0
Angle	PBC	40	34	3
Side	PC	41	14	2
Angle	CPB	69	15	50

Therefore, of the Bend:

		G.	M.	S.
Longitude	♉ [Taurus]	8	3	10

		G.	M.	S.
Latitude	B. [North]	48	46	0

Stars V and VI

V. GENU [The Knee of Cassiopeia]

	G.	M.
Between this star and Lucida Arietis [Lucida Υ]:	37	27
Between the same and Aldebaran [δ]:	55	23 $\frac{1}{3}$

Diagram. A spherical triangle with apex P at top, interior point C, side descending to A at right; a point B is set low at the lower left, with curved arcs joining the points. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Lucida Arietis [Lucida Υ]
- B: Aldebaran [δ]
- C: The Knee of Cassiopeia [Genu Cassiopeae]

I. Triangle B P A.

		G.	M.	S.
Side	PB	95	30	30
Side	PA	80	3	0
Angle	BPA	32	7	0
Side	BA	35	31	56
Angle	ABP	64	17	46

II. Triangle B A C.

		G.	M.	S.
Side	BC	55	23	20
Side	AC	37	27	0
Side	AB	35	32	0
Angle	CBA	46	6	8

III. Triangle B P C.

		G.	M.	S.
Side	BP	95	30	30
Side	BC	55	23	20
Angle	PBC	18	11	38
Side	PC	43	38	7
Angle	BPC	21	51	45

Therefore, of the Knee:

		G.	M.	S.
Longitude	♈ [Taurus]	11	57	0
Latitude	B. [North]	46	22	0

VI. CRUS [The Leg of Cassiopeia]

	G.	M.
Between this star and Lucida Arietis [Lucida ♈]:	40	13⅔
Between the same and Capella:	32	46½

Diagram. A spherical triangle with apex P at top, interior point C, side to A at lower left and B at lower right; a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: Lucida Arietis [Lucida ♈]
- C: The Leg of Cassiopeia [Crus Cassiopeae]

I. Triangle A P B.

		G.	M.	S.
Side	PA	67	9	30
Side	PB	80	3	0
Angle	APB	44	11	0
Side	BA	44	6	40
Angle	PAB	90	30	17

II. Triangle C A B.

		G.	M.	S.
Side	CA	32	46	30
Side	CB	40	13	40
Side	BA	44	6	40
Angle	BAC	64	54	28

III. Triangle A P C.

		G.	M.	S.
Side	CA	32	46	30
Side	PA	67	9	30
Angle	PAC	34	35	49
Side	PC	42	31	10
Angle	APC	27	3	12

Therefore, of the Leg:

		G.	M.	S.
Longitude	♈ [Taurus]	18	49	30
Latitude	B. [North]	47	28	50

Stars VII and VIII

VII. EXTREMA PEDIS [The Tip of the Foot (of Cassiopeia)]

	G.	M.
Between this star and Lucida Arietis [Lucida ♈]:	44	2½
Between the same and Capella:	30	18½

Diagram. A spherical triangle with apex P at top, interior point C, side to A at lower left and B at lower right; a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: Lucida Arietis [Lucida ♈]
- C: The Tip of the Foot [Extrema Pedis]

I. Triangle A P B.

		G.	M.	S.
Side	PA	67	9	30
Side	PB	80	3	0
Angle	APB	44	11	0
Side	BA	44	6	40
Angle	PAB	90	30	17

II. Triangle C A B.

		G.	M.	S.
Side	CA	30	18	0
Side	CB	44	2	30
Side	BA	44	6	40
Angle	BAC	73	38	15

III. Triangle A P C.

		G.	M.	S.
Side	PA	67	9	30
Side	CA	30	18	0
Angle	PAC	25	52	2
Side	PC	41	6	10
Angle	APC	19	57	10

Therefore, of the Tip of the Foot:

		G.	M.	S.
Longitude	♈ [Taurus]	26	15	20
Latitude	B. [North]	48	54	0

VIII. DEXTER CUBITUS [The Right Elbow (of Cassiopeia)]

	G.	M.
Between this star and Lucida Arietis [Lucida ♈]:	39	56½
Between the same and Capella:	48	9½

Diagram. A spherical triangle with apex P at top, interior point C, side to A at lower left and B at lower center; a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: Lucida Arietis [Lucida ♈]
- C: The Right Elbow [Dexter Cubitus]

I. Triangle A P B.

		G.	M.	S.
Side	PA	67	9	30
Side	PB	80	3	0
Angle	APB	44	11	0
Side	BA	44	6	40
Angle	PAB	90	30	17

II. Triangle B A C.

		G.	M.	S.
Side	CA	48	9	30
Side	CB	39	56	30
Side	BA	44	6	40
Angle	BAC	56	17	42

III. Triangle A P C.

		G.	M.	S.
Side	PA	67	9	30
Side	CA	48	9	30
Angle	PAC	43	12	34
Side	PC	40	35	51
Angle	APC	51	37	13

Therefore, of the Right Elbow:

		G.	M.	S.
Longitude	♈ [Aries]	24	15	20
Latitude	B. [North]	49	24	30

Stars IX and X

IX. PES CATHEDRAE [The Foot of the Chair (of Cassiopeia)]

	G.	M.
Between this star and Lucida Arietis [Lucida Υ]:	42	29
Between the same and Capella:	41	53½

Diagram. A spherical triangle with apex P at top, interior point C, side to A at lower left and B at lower right; a base curve with points D, E, F. Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: Lucida Arietis [Lucida Υ]
- C: The Foot of the Chair [Pes Cathedrae]

I. Triangle P A B.

		G.	M.	S.
Side	PA	67	9	30
Side	PB	80	3	0
Angle	APB	44	11	0
Side	BA	44	6	40
Angle	BAP	99	30	17

II. Triangle B A C.

		G.	M.	S.
Side	CA	41	53	30
Side	CB	42	29	0
Side	BA	44	6	40
Angle	BAC	64	6	9

III. Triangle P A C.

		G.	M.	S.
Side	PA	67	9	30
Side	CA	41	53	30
Angle	PAC	35	24	8

		G.	M.	S.
Side	PC	37	45	52
Angle	CPA	39	10	25

Therefore, of the Foot of the Chair:

		G.	M.	S.
Longitude	♈ [Taurus]	6	42	5
Latitude	B. [North]	52	14	10

X. LUCIDA CATHEDRAE [The Bright Star of the Chair (of Cassiopeia)]

		G.	M.
Between this star and Lucida Arietis [Lucida ♈]:		41	20¾
Between the same and the lower [star] of the Head of Gemini [inf. Cap. ♊]:		77	25

Diagram. A spherical triangle with apex P at top, interior point C, point B at lower left and A interior toward lower center; a base curve with points D, E, F.
Labels:

- P: Pole of the Ecliptic [Polus Eclipticae]
- B: Lower [star of the] Head of Gemini [Inferius caput ♊]
- A: Lucida Arietis [Lucida ♈]
- C: The Bright Star of the Chair [Lucida Cathedrae]

I. Triangle P A B.

		G.	M.	S.
Side	PA	80	3	0
Side	PB	83	22	0
Angle	BPA	75	37	0
Side	BA	74	45	8
Angle	PBA	81	27	15

II. Triangle B A C.

		G.	M.	S.
Side	BC	77	25	0

		G.	M.	S.
Side	AC	41	20	45
Side	AB	74	45	10
Angle	CBA	42	34	18

III. Triangle P B C.

		G.	M.	S.
Side	BP	83	22	0
Side	BC	77	25	0
Angle	PBC	38	52	57
Side	PC	38	45	22
Angle	BPC	78	8	30

Therefore, of the Bright Star of the Chair:

		G.	M.	S.
Longitude	♈ [Aries]	29	11	30
Latitude	B. [North]	51	14	30

[Margin: 289]

These pages continue the framed series **DEMONSTRATIONS OF THE POSITIONS OF THE 26 STARS OF CASSIOPEIA**, treating the stars in numbered pairs across two parallel columns. For each star: the two measured arc-distances (to *Lucida* of Aries and to *Capella*) in degrees and minutes (G. M.), a small spherical-triangle diagram with its lettered points, three triangle solutions in degrees-minutes-seconds (G. M. S.), and the derived ecliptic longitude and latitude.

In the triangle solutions, **Latus** = side, **Angulus** = angle. The zodiac symbol ♉ stands for Taurus and ♈ for Aries (here used for the longitude reckoning); **B.** after a latitude marks it as boreal (northern).

XI. EXTREMA CATHEDRAE [The End of the Chair]

	G. M.
Between this star and <i>Lucida</i> of Aries [♈]	41. 32
Between the same and <i>Capella</i>	48. 3

Diagram. A spherical triangle with apex P at top and base running from A (lower left) to B (lower right), with an interior point C. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: *Lucida* of Aries [Lucida ♈]
- C: *Extrema Cathedrae* [The End of the Chair]

I. Triangle PAB

		G.	M.	S.
Side	PA	67.	9.	30.
Side	PB	80.	3.	0.
Angle	APB	44.	11.	0.
Side	BA	44.	6.	40.
Angle	PAB	99.	30.	17.

II. Triangle BAC

		G.	M.	S.
Side	CA	48.	3.	0.
Side	BA	44.	6.	40.
Side	BC	41.	32.	0.
Angle	BAC	58.	44.	39.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	48.	3.	0.
Angle	PAC	40. [?]	45.	38.
Side	PC	38.	51.	46.
Angle	APC	50.	42.	16.

Therefore for *Extrema Cathedrae*:

Longitude	♊	25.	10.	10.
Latitude	B.	51.	8.	15.

XII. IN SCABELLO AD PLANTAM PEDIS [On the Footstool, at the Sole of the Foot]

	G. M.
Between this star and <i>Lucida</i> of Aries [Υ]	45. 10½
Between the same and Capella	34. 44

Diagram. A spherical triangle with apex P at top, an interior point C, and a base running from A (lower left) to B (lower right); short construction lines descend toward additional base points D, E, F at the very foot of the figure. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: *Lucida* of Aries [Lucida Υ]
- C: The star on the Footstool [Stella in Scabello]

I. Triangle PAB

		G.	M.	S.
Side	PA	67.	9.	30.
Side	PB	80.	3.	0.
Angle	APB	44.	11.	0.
Side	BA	44.	6.	40.
Angle	PAB	99.	30.	17.

II. Triangle BAC

		G.	M.	S.
Side	BA	44.	6.	40.
Side	CA	34.	44.	0.
Side	BC	45.	10.	30.
Angle	BAC	73.	9.	31.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	34.	44.	0.
Angle	PAC	26.	20.	46.

		G.	M.	S.
Side	PC	37.	51.	25.
Angle	APC	24.	18.	35.

Therefore for the star on the Footstool [Scabellum]:

Longitude	♄	21.	34.	0.
Latitude	B.	52.	8.	30.

[Margin: 290]

XIII. QVÆ GENV PRÆCEDIT [The star preceding the Knee]

	G. M.
Between this star and <i>Lucida</i> of Aries [♈]	35. 47
Between the same and Capella	36. 55

Diagram. A spherical triangle with apex P, interior point C, base points A (left) and B (right), and construction lines reaching down to D, E, F at the foot. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: *Lucida* of Aries [Lucida ♈]
- C: The star of Cassiopeia preceding the Knee [Stella Cassiopeae Genu praecedens]

I. Triangle PAB

		G.	M.	S.
Side	PA	67.	9.	30.
Side	PB	80.	3.	0.
Angle	APB	44.	11.	0.
Side	BA	44.	6.	40.
Angle	PAB	99.	30.	17.

II. Triangle BAC

		G.	M.	S.
Side	CA	36.	55.	0.

		G.	M.	S.
Side	BC	35.	47.	0.
Side	BA	44.	6.	40.
Angle	BAC	55.	26.	7.

III. Triangle PAC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	36.	55.	0.
Angle	PAC	44.	4.	10.
Side	PC	44.	55.	30.
Angle	APC	36.	16.	30.

Therefore for the star preceding the Knee [praecedentis apud Genu]:

Longitude	♄	9.	36.	0.
Latitude	B.	45.	4.	30.

XIII. VMBILICVS [The Navel]

	G. M.
Between this star and the Foot of the Chair [Pedem Cathedrae]	4. 42½
Between the same and <i>Lucida</i> of the Chair [Lucidam Cathedrae]	6. 2

Diagram. A spherical triangle with apex P, an interior point A near the upper right, point B at the left, interior point C lower down, and construction lines to D, E, F at the foot. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: *Lucida* of the Chair [Lucida Cathedrae]
- B: Foot of the Chair [Pes Cathedrae]
- C: The Navel [Vmbilicus]

I. Triangle PAB

		G.	M.	S.
Side	PA	38.	45.	0.

		G.	M.	S.
Side	PB	37.	46.	0.
Angle	BPA	7.	32.	0.
Side	BA	4.	46.	0.
Angle	PAB	75.	9.	25.

II. Triangle BAC

		G.	M.	S.
Side	BA	4.	46.	0.
Side	CA	6.	2.	0.
Side	BC	4.	42.	30.
Angle	BAC	50.	5.	15.

III. Triangle PAC

		G.	M.	S.
Side	PA	38.	45.	0.
Side	CA	6.	2.	0.
Angle	PAC	125.	14.	40.
Side	PC	42.	28.	25.
Angle	CPA	7.	18.	3.

Therefore for the Navel [Vmbilicus]:

Longitude	♄	6.	28.	0.
Latitude	B.	47.	31.	30.

[Margin: 291]

XV. STELLVLA AD CRINES [The little star at the Hair]

	G. M.
Between this star and <i>Lucida</i> of Aries [γ]	35. 46
Between the same and Capella	44. 15½

Diagram. A spherical triangle with apex P, interior point C toward the right, base point A at the left and B at the lower middle, and construction lines descending to D, E, F. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: *Lucida* of Aries [Lucida ♈]
- C: The little star at the Hair [Stellula ad Crines]

I. Triangle PAB

		G.	M.	S.
Side	PA	67.	9.	30.
Side	PB	80.	3.	0.
Angle	APB	44.	11.	0.
Side	BA	44.	6.	40.
Angle	PAB	99.	30.	17.

II. Triangle BAC

		G.	M.	S.
Side	CA	44.	15.	30.
Side	BC	35.	46.	0.
Side	BA	44.	6.	40.
Angle	BAC	52.	16.	58.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	44.	15.	0.
Angle	PAC	47.	13.	20.
Side	PC	44.	22.	15.
Angle	APC	47.	6.	44.

Therefore for the little star at the Hair [Stellula ad Crines]:

Longitude	♈	28.	46.	0.
Latitude	B.	45.	38.	0.

XVI. VLTIMA VIRGÆ [The last star of the Rod]

	G. M.
Between this star and <i>Lucida</i> of Aries [Υ]	28. 54½
Between the same and Capella	45. 25

Diagram. A spherical triangle with apex P, interior point C at the right, base point A at the left and B at the lower middle, construction lines to D, E, F. A small ink blot obscures part of the interior near C but the lettering remains legible. Labels at right:

- P (apex): Pole of the Ecliptic [Polus Eclipticae]
- A: Capella
- B: *Lucida* of Aries [Lucida Υ]
- C: The last star of the Rod [Vltima Virgae]

I. Triangle PAB

		G.	M.	S.
Side	PA	67.	9.	30.
Side	PB	80.	3.	0.
Angle	APB	44.	11.	0.
Side	BA	44.	6.	40.
Angle	PAB	99.	30.	17.

II. Triangle BAC

		G.	M.	S.
Side	BA	44.	6.	40.
Side	CA	45.	25.	0.
Side	BC	28.	54.	30.
Angle	BAC	41.	28.	30.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	45.	25.	0.
Angle	PAC	58.	1.	45.

		G.	M.	S.
Side	PC	51.	41.	0.
Angle	APC	50.	22.	0.

Therefore for the last star of the Rod [vltimae Virgae]:

Longitude	γ	25.	30.	30.
Latitude	B.	38.	19.	0.

[Margin: 292]

This opening's four demonstrations (XVII–XX) are presented in abbreviated form: each cites the position of the two reference distances and refers the reader back to the corresponding earlier figure rather than redrawing it — *Vide Figuram, et illic Triang. PAB* ("See the figure, and there triangle PAB") — and the first triangle (PAB) is likewise carried over and not repeated. Only triangles II and III, together with the derived position, are given.

XVII. BRACHIVM SINISTR. [The Left Arm]

	G. M.
Between this star and <i>Lucida</i> of Aries [γ]	33. 21
Between the same and Capella	38. 42
For the III. figure, see [the earlier diagram], and there triangle PAB. [III. Figuram vide, et illic Triang. PAB]	

II. Triangle BAC

		G.	M.	S.
Side	BA	44.	6.	40.
Side	CA	38.	42.	0.
Side	BC	33. [?]	21.	0.
Angle	CAB	50.	48.	42.

III. Triangle PAC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	38.	42.	0.
Angle	PAC	48.	41.	35.

		G.	M.	S.
Side	PC	46.	53.	51.
Angle	APC	40.	2.	10.

Therefore for the Left Arm [sinistri Brachii]:

Longitude		♄	5.	50.	30.
Latitude		B.	43.	6.	10.

XVIII. CVBITVS SINISTER [The Left Elbow]

				G. M.
Between this star and <i>Lucida</i> of Aries [♈]				33. 38
Between the same and Capella				39. 29
For the III. figure, see [the earlier diagram], and there triangle PAB. [III. Figuram vide, et illic Triang. PAB]				

II. Triangle BAC

		G.	M.	S.
Side	CA	39.	29.	0.
Side	BC	33.	38.	0.
Side	BA	44.	6.	40.
Angle	BAC	51.	0.	50.

III. Triangle PAC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	39.	29.	0.
Angle	PAC	48.	29.	27.
Side	PC	46.	31.	51.
Angle	APC	41.	0.	11.

Therefore for the Left Elbow [sinistri Cubiti]:

Longitude		♄	4.	52.	20.
Latitude		B.	43.	28.	0.

XIX. QVÆ APVD EXTREMAM SELLÆ [The star near the End of the Saddle]

	G. M.
Between this star and <i>Lucida</i> of Aries [Υ]	43. 2
Between the same and Capella	48. 31
For the XII. figure, see [the earlier diagram], and there triangle PAB. [XII. Figuram vide, et illic Triang. PAB]	

II. Triangle BAC

		G.	M.	S.
Side	BA	44.	6.	40.
Side	CA	48.	31.	0.
Side	BC	43.	2.	0.
Angle	BAC	60.	40.	40.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	48.	31.	0.
Angle	CAP	38.	49.	27.
Side	PC	37.	20.	46.
Angle	APC	50.	44.	20.

Therefore for the star near the End of the Saddle [quae apud extremam Sellae]:

Longitude	Υ	25.	8.	0.
Latitude	B.	52.	39.	0.

XX. QVÆ INTER IX. & XXII. [The star between (stars) IX and XXII]

	G. M.
Between this star and <i>Lucida</i> of Aries [Υ]	45. 5½
Between the same and Capella	36. 14½

For the XII. figure, see [the earlier diagram], and there triangle PAB. [XII. Figuram vide, et illic Triang. PAB]

II. Triangle BAC

		G.	M.	S.
Side	BA	44.	6.	40.
Side	CA	36.	14.	30.
Side	BC	45.	5.	30.
Angle	BAC	72.	2.	27.

III. Triangle APC

		G.	M.	S.
Side	PA	67.	9.	30.
Side	CA	36.	14.	30.
Angle	PAC	27.	27.	50.
Side	PC	37.	12.	10.
Angle	APC	26.	48.	28.

Therefore for the star between IX and XXII [quae inter IX. & XXII.]:

Longitude	♄	19.	4.	0.
Latitude	B.	52.	48.	0.

The framed per-star demonstrations of the Cassiopeia stars conclude here (stars XXI–XXVI). Each box gives the two reference angles measured to the bright stars, a cross-reference to the relevant figure and triangle, the two spherical triangles solved (II. Triangle BAC and III. Triangle APC), and the resulting longitude and latitude of the star. The angular quantities are in degrees (G.), minutes (M.), and seconds (S.).

XXI. Extrema Scabelli [The outermost star of the Footstool]

	G.	M.
Between this star and the bright star [Lucidam] ♀	48	54
Between the same and Capella	37	42½

XII. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BA	44	6	40
Side	CA	37	42	30
Side	BC	48	54	0
Angle	BAC	77	53	6

III. Triangle APC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	37	42	30
Angle	PAC	21	37	11
Side	PC	33	47	12
Angle	APC	23	55	10

Therefore, for the outermost star of the Footstool:

		G.	M.	S.
Longitude	γ	21	57	20
Latitude	B.	56	13	0

XXII. Media Scabelli [The middle star of the Footstool]

	G.	M.
Between this star and the bright star γ	47	23
Between the same and Capella	36	15½

XII. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BA	44	6	40
Side	CA	36	15	30
Side	BC	47	23	0
Angle	BAC	76	12	30

III. Triangle APC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	36	15	30
Angle	PAC	23	17	47
Side	PC	35	33	0
Angle	APC	23	43	34

Therefore, for the middle star of the Footstool:

		G.	M.	S.
Longitude	♄	22	9	0
Latitude	B.	54	27	0

XXIII. Quae Genu sequitur [The star that follows the Knee]

	G.	M.
Between this star and the bright star γ	36	14½
Between the same and Capella	34	59½

XIII. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BC	36	14	30
Side	AC	34	59	30
Side	AB	44	6	40
Angle	BAC	56	50	26

III. Triangle PAC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	34	59	30
Angle	PAC	42	39	51
Side	PC	45	2	24

		G.	M.	S.
Angle	APC	33	19	0

Therefore, for the star that follows next at the Knee:

		G.	M.	S.
Longitude	γ	12	33	30
Latitude	B.	44	57	30

XXIII. Praeced. in Virga [The preceding star in the Rod]

		G.	M.
Between this star and the bright star γ		31	41
Between the same and Capella		44	15

XVI. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BA	44	6	40
Side	CA	44	15	0
Side	BC	31	41	0
Angle	BAC	46	7	10

III. Triangle PAC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	44	15	0
Angle	PAC	53	20	7
Side	PC	48	34	40
Angle	APC	48	19	30

Therefore, for the preceding star in the Rod:

		G.	M.	S.
Longitude	γ	27	33	0
Latitude	B.	41	25	30

XXV. Sequens in Virga [The following star in the Rod]

	G.	M.
Between this star and the bright star Υ	31	23
Between the same and Capella	43	3

XVI. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BA	44	6	40
Side	CA	43	3	0
Side	BC	31	23	0
Angle	BAC	46	10	0

III. Triangle APC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	44	15	0
Angle	PAC	53	19	47
Side	PC	48	44	50
Angle	APC	46	44	34

Therefore, for the following star in the Rod:

		G.	M.	S.
Longitude	Υ	29	8	0
Latitude	B.	41	15	0

XXVI. Penultima Virgae [The next-to-last star of the Rod]

	G.	M.
Between this star and the bright star Υ	29	40
Between the same and Capella	44	43

XVI. See the figure, and there the triangle PAB.

II. Triangle BAC

		G.	M.	S.
Side	BA	44	6	40
Side	CA	44	43	0
Side	BC	29	40	0
Angle	BAC	42	54	20

III. Triangle APC

		G.	M.	S.
Side	PA	67	9	30
Side	CA	44	43	0
Angle	PAC	56	55	57
Side	PC	50	44	37
Angle	APC	49	20	30

Therefore, for the next-to-last star of the Rod:

		G.	M.	S.
Longitude	Υ	26	32	0
Latitude	B.	39	15	20

And let this suffice concerning the stars of Cassiopeia. From these demonstrations it is clear that I have not arranged their positions arbitrarily, nor taken them from the customary tables. Rather, I have derived everything from the heavens themselves, working through the triangles by reduction to numbers. I did this either by the general method [generalis Canone] reviewed above — and this especially where the stars lie close to the pole — or else, where appropriate, by the more laborious procedure through declinations and right ascensions, as set out elsewhere.

As for these same Cassiopeia stars, I have just now determined their longitudes and latitudes. I do not think it necessary to set them out separately here in a dedicated table for the eye, since that has already been adequately accomplished in its proper place by the general canonical determination for the year 1600, with about 24 further minutes [Scrupulis] now added [for precession]. Moreover, in the chapter that follows I have decided to set out for the eye, in a convenient table, those positions which it is useful to apply from here on — referred to the year in which the New Star shone forth, and reckoned with respect to both the ecliptic and the equator.

Here, then, I shall bring to a close this first part of the present Book — the part in which the restoration of the solar course, together with the cycle of the Moon and the accurate rectification of the fixed stars, has been amply carried out (the foundations of the whole reform of astronomy having thus been laid). After it I shall append, in place of a colophon, the following exhortatory poem addressed to the students of this art; and with that I shall at last pass on to the treatment of the New Star which I proposed.

PARAENETICUM AD ASTRONOMIAE CULTORES

[An Exhortation to the Devotees of Astronomy]

Now the road lies open, untrodden through many ages before — won out at last by great and watchful toil — that I may be allowed to climb the once-unscaled summits of Heaven and pass within the lofty halls, the dwellings of the gods: whether the wish be to chart the Fixed Stars, or the Wandering Fires that move along their varied tracks, and to test the course and place of each star, that the Wonders of highest Jove may stand confirmed.

Come then, O young men, in whom there is keen and lofty vigor of mind, and the favor of your native genius — you in whom, from your very birth, Urania has breathed the renowned love of the gods' Heaven, and granted you to set the Earth and earthly things below the goods of the upper air: you who do not heed the reckless judgments of the crowd, nor the sour voices of the idle — those who, like moles sent into dark caverns, choose to live forever blind, just as they wish to be.

Breathe your spirits here, eager; turn here, leaving the mob behind you; and do not, for the sake of private gain or your own country's good, withhold your Mind, that part which is the divine portion of Heaven. Bring here, with one accord, your zeal and your labor; come here together, that it may be granted to relieve the weary King Alphonso [Alfonso X] — who carried a burden not matched by his strength, he who lately, as successor, took up the load of his neighbor Atlas. And come, so that great Copernicus may feel a ready help at hand, lest, while he confidently undertakes to set himself to a labor worthy of Hercules, he sink beneath an unequal weight. So too, lest the poles of Atlas — and the broken columns of Alcides [Hercules] — be forced to bear the ruin that now, at this very moment, totters upon them, and the Earth, shifting from its station, give birth to a barbarism of strangers (the gross ignorance of Heaven)

which it would beget — confounding all: men, cattle, and wild beasts alike, overturning them in doubtful chance and blinding darkness, and mingling the courts of the World with ancient chaos once more. Forbid this wrong; meet the impending harm head-on, and climb with me the lofty Olympus by your strength, to close in good time the gaping cracks, and to brace the vaulted ceiling of Heaven with new cross-beams, before the whole Engine of the world falls apart.

Is there anyone, then, here present, who would earn from this a fair Crown — conspicuous with pure gold, with gems, with ivory, and with glowing red bronze [pyropo], and more enduring still, set apart to last forever — anyone who would wish it, and to join his spirit with the spirits above? Is there anyone, among all the Earth-dwellers the World contains — numberless as they are — who will be granted to hold such sublime things dear? Is there anyone who longs to recognize the Author of the World through the things he has founded, and so many marvels to behold in the Heavens? Are you all alike silent before so great a quest?

What good is it to mutter? The hand must be put to the work, that the hidden Mysteries of Heaven may at last lie open. If ambition, gain, ignorance, or luxury drag any of you back from ventures so high, and thrust you down to the depths — then at least let them spare others, and not hold back the highest goods. As for myself: if the divine Powers smile upon me with a kindly face, and grant me to overcome whatever obstacle stands high before me, with steadfastness of spirit, as I have done so far — then I will strive willingly, with all my sinews, to open to Earth's children the inmost places of great Heaven, and to lay bare its hidden recesses. Only do you, wise Founder of marvelous Olympus, say yes, and bring your aid to one who records your stupendous deeds.

PART TWO

PART TWO, dealing specifically with the New Star, and comprising what can be deduced and made plain about its appearances from my own observations.

CHAPTER THREE

On the time and duration of this star's unusual appearance, and a general account of what was observed in it during that period as regards its visible magnitude, form, and color.

The New Star, whose phenomena I principally intend to set down in writing here so that posterity may come to know something certain about so unusual and astonishing a spectacle shown to our age from heaven, first shone forth to the whole world in the year 1572 from the birth of Christ our Redeemer—according to the reckoning received from Dionysius, although certain modern correctors of chronology not unreasonably conclude that this reckoning falls short by one year. It began, however, near the end of that same year, in the next-to-last month, November, close to the star's first appearance—or at least within the first ten days of that month [in prima eius Triade]. As for the actual day on which it first rose, nothing certain is established; nor does the claim that some people believe it was seen in October deserve any sure trust.

I conjecture, with some probability, that it had its first beginnings around the new moon, which fell on the fifth day of November. For before that time no one—so far as I know—whom one might safely trust had noticed it.

I myself first caught sight of it on the 11th day of November, when the air over our horizon had, with the help of several preceding days, become somewhat clearer—and I saw it on the occasion I shall now relate.

At that time I was staying with my maternal uncle, a most noble man and most eager for every liberal pursuit, Steno Bille [Sten Bille], lord of Vandås and Råbelöv and so on, who passed away a few years ago. He was then living in a certain royal fief called Herrevad, which had once been a monastery. Drawn both by the pleasant company of my uncle and by the charm of the place, I was spending some time there. For I had only recently returned from Germany, and I did not wish to live alone at my own seat at Knudstrup—though that lay nearby, so that I could go over there whenever I pleased. And since this uncle of mine was

himself thoroughly learned, gave generous support to the higher studies, and pursued me and my efforts with singular affection, once he had discovered that I was deeply devoted to chemical and spagyric [Spagyricis] preparations as well, he had granted me a fairly spacious house outside the walls of the said monastery, where I could carry on those alchemical labors [Pyronomicos illos Labores] privately and conveniently, on my own.

Now it happened that, on the aforesaid day a little before supper, I had gone to that house for the sake of inspecting and arranging my chemical work—as I otherwise did two or three times a day—and as I was returning, walking back (for this house was some little distance from the gates of the monastery) and gazing here and there at the sky, since a clearer air seemed to promise, as I wished, that the astronomical observations could be continued after supper—behold, near the zenith, a certain unfamiliar star, gleaming with a radiant brilliance, struck my eye and dazzled my sight as I looked, appearing all at once.

Filled with wonder, and as though thunderstruck, I stood stupefied; and fixing my eyes intently upon that star, I gazed at it for a while. Noticing that it was set right among the stars that antiquity had assigned to the constellation Cassiopeia, I was quite certain that no star of this kind had ever before blazed forth in that place. (For from boyhood all the stars that lie distinctly visible to the eye throughout the whole sky had long been familiar to me.) I was led into such doubt over the incredibility of the matter that I did not blush to distrust the testimony of my own eyes. And so, turning to the servants who were accompanying me, I asked them whether they too could see a certain very bright star in the place I pointed out near the zenith. They at once answered with one voice that they could see it plainly and that it was exceedingly brilliant. But, still uncertain about their corroboration on account of the novelty of the matter, I inquired of some peasants who happened to be passing by in their wagons at that same time whether they could make out any star up on high. They exclaimed that they could see a huge star there which they had never before noticed so high up.

At last, confirmed that what I saw was no deception but that an unaccustomed star really did exist there, and astonished beyond all measure that some new phenomenon had befallen the heavens, comparable to the rest of the stars, I immediately set up my instrument and undertook to measure its position and its distance from the neighboring stars of Cassiopeia, and to note more carefully those features that lay open to the eye concerning its visible magnitude, form, color, and other characteristics.

This star, moreover, lasted throughout the whole of the following year, and indeed all the way up to the beginning of spring in the year 1574, when, in the month of March, it ceased to be visible.

It stood, however, perpetually fixed in one and the same place in the sky, never departing—so far as could be discerned by any of the senses—into this part or that, but always preserving the same arrangement with respect to the neighboring stars of Cassiopeia.

The form of this star was perfectly round, no different from the other lights of the sky. For it did not throw out any tail or hair, whether toward some one direction or all around about, as is customary in comets; rather, like the other stars, it emitted rays flashing out on every side from the body itself, just as happens with the larger stars; and with its exceedingly scintillating, quivering light it did so almost more than is seen in the rest of the stars.

Its apparent magnitude, from the beginning, surpassed all the fixed stars, even those of the first rank, and so exceeded even Sirius [Caniculam] and Lyra [Lynam]. Indeed, it even surpassed somewhat, in its visible size, the star of Jupiter as it then was—at its acronychal rising [Acronychiam], and also approaching nearer to the Earth by reason of the perigee of its eccentric [Perigaei Eccentrici] (for I am pleased here to speak with the opinion received in the schools), on both of which accounts it appeared larger than usual—so that it most closely rivaled the torch of Venus when, drawing nearer to the Earth, she shines with a fuller face. From the very beginning, too, it was conspicuous for its very great body, as though it had suddenly been formed into so great a mass; and it preserved this breadth and majesty of light, as it were at the same pitch, for nearly the whole of November—so much so that it could then be seen distinctly by very many people who had keen eyesight, even in broad daylight, even at noon itself, when the air was clear: a thing granted to no other stars except Venus alone. Indeed, even at night, very often [Noctu saepenumero]...

in number, it shone through clouds that were not too dense, while the other stars remained hidden.

This eminence of magnitude, however, the star did not retain through its whole duration. Instead it gradually fell off and diminished, until it ceased to exist altogether — and this by the following proportional sequence.

In November (as I have said) it equaled Venus in visible size. Through December it nearly rivaled the planet Jupiter. In the January of the following year it shone a little smaller than Jupiter, yet somewhat larger than the brighter stars of the first

magnitude; and in February and March it was equal to these. So in April and May it matched stars of the second magnitude, and as it went on declining in this way, through June, by July and August it became equal in size to the fixed stars of the third magnitude — so much so that it was then very nearly identical to the larger stars in Cassiopeia, which are likewise reckoned of the third rank. Afterward, through September, it grew steadily fainter, and in October and November it presented stars fourth in order; and then, especially in the month of November, it appeared not unlike the eleventh star of Cassiopeia, to which it was closest, so that the one could scarcely be told apart from the other. Furthermore, at the end of that year and in the following January, it barely exceeded stars of the fifth form. In February it faintly sketched stars of the sixth and smallest sort, until at last, in the month of March, it became so faint that it ceased to be visible at all.

Now just as, while it lasted, it altered its visible bodily size by gradually diminishing it, so too it did not everywhere display the same color of its inherent light. At the start, when it was seen equal in magnitude to Venus and Jupiter, it shone with a whitish, bright, gleaming light, pleasing and

agreeable to the eye, comparable and similar to those same beneficent planets. Afterward this gleaming brilliance changed into a kind of yellowish tincture, so that around the beginning of the spring season of the year 1573 it degenerated into a kind of Mars-like ruddiness — perhaps because its light had by then become more compressed and condensed. For at that time it grew red like Aldebaran, or like the star in the right shoulder of Orion [Betelgeuse]. Yet it did not appear as ruddy as the said star in Orion's shoulder, but came closer in color to Aldebaran.

Then, near the end of spring — especially in the month of May — it took on a kind of leaden-pale whiteness, such as appears to underlie the planet Saturn; and this color it kept thereafter almost until its disappearance, except that the closer it came to its end, the more it gradually turned that same color murkier, duller, and more obtuse. Nonetheless it twinkled continually, even right up to the final limit of its vanishing, in proportion to the measure of light and size it then possessed — so that this twinkling, or vibration of the light, accompanied the very decrease of its magnitude and brightness proportionally; and although it struck the eye successively smaller, it never failed entirely so long as any trace of the star remained.

In considering these matters, joined as they are with equal wonder, I judge it worth noting that this recent star imitated, by the law already described, all the other stars — both the fixed and the wandering (the luminaries alone excepted,

which are not properly called stars) — in magnitude, light, and color, at least at some point during its duration; so much so that nothing of this kind ever appeared without some star, whether among the planets or the fixed stars, being found most like it — except that in twinkling

it did not resemble the wandering stars, though in this respect it had something in common with the fixed stars.

Such was the appearance of this unusual heavenly body, and its outward character — as regards the circumstances of its form, magnitude, light, and color, and the alterations of these throughout its whole duration — carefully observed. For although the meanwhile varied disposition of the air, not always uniformly clear, may sometimes have presented each of these particulars to the eyes a little differently, and although this also varied according to the differing keenness of vision of the observers, still that was rather accidental, and did not last long. Hence the things I have recorded do not come to be reckoned from some momentary and rapidly passing act of seeing, impeded by some intervening obstacle, or from an aberration; rather, they were apprehended in this way when the air was clearer, after being repeated often over a long time and compared with one another in careful consideration. There remains no doubt that they are correct.

That this stranger star stood, throughout the whole time of its duration, in exactly the same place of the heavens, like the fixed stars, I have already said. For it was found to possess no proper motion of its own in the interim, but obeyed only the universal daily revolution — which, moreover, it imitated most perfectly and constantly.

And the arrangement by which it kept its position relative to the nearest stars of Cassiopeia presented itself in the following manner.

With the three more principal and more conspicuous stars of this constellation, which are held to be of the third magnitude — namely, the one that is higher in the middle of the Chair [Catheda], and the one toward the breast,

called Schedir, and the third, which is next to the bend near the thigh — it formed a quadrilateral figure, or a kind of rhombus of unequal sides, the form the Greeks call a trapezium. And it was quite close to the star that is in the middle part of the seat, of the fourth magnitude and eleventh in number, being a little removed from this one toward Cepheus — so much so that this star marks out the place of this recent star with the finger of its left hand, as its disposition is depicted on the

mechanical globes. Thus this strange star was placed on the border of the Milky Way, where its northern edge, near Cassiopeia, faces the Arctic Pole.

Such, as I have related up to now, was the duration, appearance, and constitution of the New Star, so far as it could become known from direct inspection and general consideration. This was plain even to those who had acquired either no knowledge of the stars at all, or only a very slight one.

It also happened that unskilled people — wagon-drivers, couriers, sailors, and the like, untrained folk — in Germany and elsewhere noticed this star here and there long before the learned, or even before those who profess the study of astronomy, did, and were the first to point it out to others. Some of those who afterward published their own opinions about this star thought this worth wondering at, as though some special meaning were tacitly hinted by it — namely, that this very rare spectacle became known first to uncultivated men, not to the lettered and those schooled in the academies. But I, for my part, judge that there is no miracle underlying the fact that men ignorant of the stars caught sight of this heavenly body before others who pride themselves on their knowledge of it. For in our age things are so arranged that nearly all who devote any effort to learning, at least in those arts which

what is profitable and ostentatious, but neglect what is true. Since that gain is a worldly vanity, and is concerned with earthly things, most of those who put themselves forward under the name of some branch of learning bend their whole attention to the Earth alone, much like the rest of the brute animals, which seek their food and the necessities of life from the soil alone. They never raise their gaze on high to look up at those heavenly and most splendid lights of the sky — afraid, perhaps, that the Sun and the blaze of the stars might strike too violently against eyes already dimmed by their earthly defilements.

Indeed, even among those very men who, whether by natural bent, by training, or by the profession from which they earn their living, are thought to practice astronomy, there are some who do not pursue it in the heavens themselves (as would be fitting), but instead deal with it under a roof, by means of a few small pages, tables, and figures, and yet imagine they have done their duty well enough. So it is that very many of them — it is shameful to admit — are wholly destitute even of any direct knowledge of the stars, and think it enough if, for the sake of profit, they compile calendars and nativities out of tables and ephemerides, or, to put it more truly, have learned to spoil good paper with these trifles. And so, for the sake of a paltry gain, they belittle this most noble art and brand their own

reputation with disgrace — not thinking it unbecoming, perhaps because they themselves are unaware of it.

Regiomontanus [Regiomontanus] too once complained of such astronomers: that they are sluggish and not at all keen and diligent followers of their predecessors, and that they practice this lofty art (as it deserves to be called) not in the heavens themselves but in some hut — so much so that, had he placed it in a steam-bath near the furnace, or in a tavern, he would perhaps have said nothing out of place. Thus the matter seems not so much to deserve wonder as rather to be deplored: that untrained dabblers, the most ignorant sort of men, should sooner and more readily

take notice of the star we are speaking of, newly arisen in the sky, than those men, puffed up with I-know-not-what abundance of learning, who in the Schools loudly proclaim themselves — even among the very ones who scrutinize this celestial part of philosophy.

Therefore, if any marvel lies hidden here, it consists rather in this: that these unlearned men were sharper-eyed than those who boast of their learning, and that they turned their attention sooner to the things lately on view in the heavens than did most of the petty astrologers, who go looking for the stars in books.

For since wagoners, travelers, and sailors are usually out under the open sky, and often journey by night as much as by twilight, it ought to be no great wonder that they notice something new in the heavens sooner than those who, mostly hidden away in their heated rooms, scarcely come out of their shells like snails — or, if they do, look down at the earth instead, and at what lies before their feet, gazing about only in the manner of moles, scarcely lifting their faces to that lofty Aether overhead, and indeed scarcely even that, much less examining the heavens with the attention they deserve. But while one may complain of these things, it is not so easy to set them right, since nearly all mortals are fixed fast upon earthly matters. So, leaving such men aside, let us carry through to the end our account of our star.

Since, then, this newcomer star chose for itself a fixed seat in the northern quarter of the sky, next to the constellation of Cassiopeia [Cassiopeia], for as long as it offered itself to the world's view, I think I shall not be acting amiss if I present a complete delineation of the asterism of Cassiopeia together with all its stars.

But before I do so, let me digress a little to the records associated with this figure set in the heavens. For since this constellation — now, in our own time, by the occasion of this New Star [New Star of 1572] —

among those people who otherwise have a less than thorough grasp of other matters, has, contrary to all expectation, come to be noticed and grown famous because the star arose near it in so unusual a way — a thing still fresh in memory — it will not be out of place if I recount the history of Cassiopeia, and the fables the ancient poets built upon it, explaining why she is said to have been placed back among the stars and recalled to this spot.

Cassiopeia is reported to have been the wife of Cepheus, king of the Ethiopians (who is likewise set in the sky behind her), a woman of such loveliness of form that she not only surpassed in beauty all the women of her own age, but even dared to contend over the excellence of her beauty with the Nereids — the sea-nymphs whom Hesiod, in his *Theogony*, counts as fifty — and indeed with Juno herself, as some report. In her excessive self-satisfaction and arrogance, she presumed to set herself above the goddesses and, on account of her elegant appearance, to despise them. From this it came about that the Nereids — or Juno — taking this ill (for there is nothing that offends womankind more than contempt for their beauty, since their chief esteem rests in outward appearance and adornment) conceived a vast hatred and a longing for revenge against Cassiopeia. Juno first warned her that all outward grace of mortals, and every excellence of beauty, is of no account compared with things divine, so that beside these it should appear utterly base. And since Cassiopeia still would not acknowledge her own unworthiness, lest such uncommon arrogance go unpunished, Juno — or else the Nereids — obtained from Neptune that he should drive a sea-beast, a whale [Cetus], huge, monstrous in its vastness, and horrible to look upon, into the region where she lived; and this beast, laying waste the fields and country dwellings, and afflicting the inhabitants with great calamity,

did not even spare the cities themselves, but with the bulk of its body set about overthrowing them as well. Terrified by this punishment and disaster, Cepheus — slaughtering victims in the customary way and consulting the Oracle — inquired into the causes of such great evils and the manner of deliverance. When the response came, it was that Cassiopeia had earned this vengeance by her proud presumption, and that it could not be expiated unless his only daughter, Andromeda, were chained to the rocks to be devoured by the monster. Understanding this, the father, though grieved, judged it better to take thought for the whole region, and allowed his daughter to be set out near Ioppe, a city of

Ethiopia, and bound to the rocks. But while the gods were taking pity on the maiden, undeserving of this fate, and were turning aside an unworthy butchery, it happened that Perseus, passing that way with the head of Medusa, set himself against the beast as it advanced and was already on the point of swallowing the maiden. Displaying the serpents of the Gorgon, he turned part of it to stone, and with the sword he held in his hand cut the other part to pieces. So, having freed Andromeda — both her parents being unaware of it — he took her as his wife. Moreover, when Phineus, the brother of Cepheus, who was jealous of him and sought her for himself, and on that account was laying snares for his life, Perseus reduced him to stone by the venom of the head he carried; then, migrating to Argos with his wife Andromeda, he is said to have grown old there. So much for the fabulous tales of the ancients.

It is plausible to gather from these stories that the most ancient Ethiopians, who lived beneath the Equator, in the middle region of the Earth between the two

Poles, observed all the stars rising more or less directly, and the planets themselves ascending high toward the top of their heads, and so meeting their eyes more fully and more plainly. They observed them frequently — with every night also being twelve hours long, so that throughout the whole year they could examine the stars most conveniently — and they were not hindered by such frequent clouds or murky weather in that sweltering Zone of the stars...

in withdrawing the sight of the stars from view. Those men, I say, were more devoted to astronomy than other peoples because they were descended from Chus [Cush], the firstborn of Cham [Ham] — and for that reason they were black, as though marked out for Cham's mockery. Without doubt they had drawn their knowledge of astronomy from Noah their father and from his brothers — the same knowledge that, before the Flood, had been handed down from Adam through his sons, as Iosephus [Josephus] testifies — and they had carried that same knowledge into Ethiopia, so that their descendants cultivated this art all the more diligently. And since Cepheus laid the foundations of the Ethiopian kingdom — whose wife was Cassiopeia, whose daughter was Andromeda, and whose son-in-law was Perseus — and since the story of these figures was famous among the Ethiopians, they inscribed their names upon the stars so that it too might be perpetual. They commemorated the king and queen, together with their daughter and son-in-law, among the constellations, toward the North Pole, joining them as it were into a single tract of the heavens, so that by this means the memory and fame of the first founders of the kingdom might be the more illustrious and might

endure longer than if they had set down these annals on parchment, or even carved them in marble and stone.

It is equally possible that Cepheus and Perseus were themselves astronomers, after the manner of those kings, or that they generously fostered the practitioners of the art — and that they were therefore set among the stars by these practitioners on account of the propagation and promotion of the art, while the queen and her daughter were honored just as highly on account of having such distinguished husbands.

There also arose at that time the stars that they assigned to Queen Cassiopeia, together with the vernal equinox, that is, the first point of Aries [γ] — the beginning under whose sign the kings were accustomed to be inaugurated — as though they were descended from their first mother Cassiopeia (who in earlier times was perhaps more probably called *Cussiopea*). And this is the more credible history of Cassiopeia, and of the occasion on which she found her place among the stars; the rest [cae-]

[ce-]tera appear to be inventions of the poets. Now these four figures — of Cepheus, Cassiopeia, Andromeda, and Perseus — are set up jointly, as it were in a triangular configuration [Figura Triquetra], whose apex Cepheus occupies toward the Pole, while Perseus and Andromeda hold the base; Cassiopeia, however, sits in the middle, in the area, upon her throne. By the poets she is imagined to have been placed among the stars because she dared, with such arrogant presumption, to contend with Juno (or with the Nymphs) over excellence of beauty, and shamelessly to scorn the goddesses before her face. The intent was that she should be a perpetual example to mortals of the pride to be shunned, and that she should therefore be so arranged as to rise unbecomingly, with her head thrown back. And some say that, for the same rashness, she sits in a *siliquastrum* [a kind of seat or instrument of punishment]; while perhaps, for the same reason, she holds in her hand a reed [arundinem], as a hieroglyph of inflated pride and frivolity.

And so much for the fabulous narrative of Cassiopeia — even if these things are perhaps excessive. I shall nevertheless add, on the same subject, the verses of Aratus [Aratus] as rendered into Latin by Cicero [Cicero], by Germanicus Caesar [Germanicus], and by Avienus [Avienus], so that it may be established that these are partly fictitious and partly true annals of the ancients.

The version of Aratus's verses by Cicero runs thus.

She slips down at the same moment, seeking her tearful daughter, Cassiopeia, nor does she fall gracefully from the sky; for she is carried head foremost, the crown of her head touching the ground first, her seat overturned behind her shoulders. This punishment the kindly Nereids impose upon her, with whom, as the story goes, she dared to contend in beauty.

Germanicus Caesar renders it thus.

Where the winding Serpent [Anguis] looks back at her fixed flank, Cassiopeia sits on high above the very man. Bright too she shines all night long when the Moon glows with full sky; yet she is brief, adorned with few flames among the stars. As a little key thrusts under the iron-fitted teeth [of a lock] and shakes them, and draws back the fastenings of the bolt at the door, so she too, with her stars thus arranged, dread in her face,

so she stretches out her palms, as if about to lament her abandoned Andromeda — atonements not deserved, the unjust ones of her mother.

Avienus rendered the same passage thus.

Again, if you should bend your gaze down a sloping path, let the first coil of the bent Dragon [Spira Draconis] be left to you; you will behold the ill-fated Cassiopeia, yet not much, even so, when the Moon fills the sky with all its light, so that its golden torch overcomes the gloomy Night. The mother meets the searching eyes; they are present, bright to the grieving one — a faint fire glows, and barely, a dim light it is for the mother: scarcely such as Caria once knew, entering through the stubborn bolts with its key — she is formed of distant stars, and her shoulders are scarcely stretched into narrow span, recalling, too late, the fates of her daughter.

But I do not wish to dwell on these matters any longer; nor did I adduce even these because I judge them to be of great importance, or to bear greatly upon the subject we are setting out to clarify. For I am not of the opinion held by some — that in the figures with which the stars have been marked since antiquity there resides some special power [Energia] — unless perhaps in a few cases, and from the situation and position of the stars themselves, where it would arise from the nature of the stars rather than from the figure itself, which is plainly fictitious, and would come from some other source. Let the petty astrologers [Astrologastri] prattle here whatever they please: the heavens are not on that account liable to

falsehoods, just because the Earth teems with these things through the fault of men. Yet I have judged it by no means idle to review these inventions of the ancients — partly on account of that *gnome* or ethical lesson by which men are deterred from arrogance, lest they grow proud over the gifts of God, and lest, by haughty contempt, they provoke against themselves not only their neighbors but God himself (with undoubted vengeance following from on high); and partly so that the history of Cassiopeia, and the occasion on which her name is believed to have been placed among the stars, might be ready to hand.

But if anyone should wish to put forward something more pious and true than what stands in need of old fables for its testimony — namely, that this unusual portent of divine power, placed beside the constellation of Cassiopeia, was set there so that worldly men might be admonished to detest complacency and pride — I do not object. For, being far too pleased with themselves, they do not look up to God, nor do they take any care for their neighbor, indulging at least their own desires while blinded by them; meanwhile, almost everywhere, boasting of the Word of God, they nonetheless tear one another to pieces under this pretext with insults and malice, while scarcely anyone does his duty. And what is most to be deplored is that those very men who ought to exhort others to piety, charity, gentleness, tolerance, and the like — the works that shine forth from our faith — and ought to lead the way, instead cover over with an outward varnish the piety that ought to be simple and inward, and so deceive the ignorant; caring nothing, or little, for love of their neighbor; laboring at least under self-love [*Philautia*], swollen with pride, avarice, and the desire for revenge; and by persecuting others, driving them rather to patience than conducting themselves with moderation and tolerance; indeed, being so at odds among themselves that by now the wars of pens are more savage than the wars of arms — the latter harming the body, the former the soul. It is therefore no wonder that the simple and untrained common folk, who hang upon the words of such men, wander off in this way and slip into byways, and — ignoring and neglecting the narrow path of truth and virtue — run all too carelessly along that broad and well-worn road of the unclean world, having set aside the eternal, true, good, and saving discipline; for the nature of Adam, earthly and corrupt though it be, is nonetheless bitter toward the best heavenly rule of Christ by itself.

Now I shall append the figures of Cassiopeia that I promised above, and that in two ways. In one way, [I shall show] the bare star, which I [myself]...

I marked down 26 [stars] — twice as many as our predecessors had (as I explained at the end of the preceding chapter, when I demonstrated their

positions from the sky itself). [The first chart is arranged] so that these stars are set out according to their proper mutual disposition, that is, by longitude and latitude (which are marked off along the margin of the quadrilateral border), each value being assigned to its own star. In the second [chart] the same stars are placed appropriately upon the painted image of Cassiopeia, in proportion to the symmetry of her limbs, with their individual numbers added — both here and there — by which they are listed in order by me. In both charts I have marked the position of the star near that eleventh small star [near the cathedra], so that at a single glance, as it were, its relation to the rest of the stars of Cassiopeia — both their relative arrangement and placement — may be plain to the eye.

It should be noted that these dispositions of the stars, and their markings in both charts, correspond exactly to their appearance in the heavens, since they have been derived into this conformity from careful observation of the sky itself. And if the arrangement of others — in globes or on charts — does not everywhere agree with this design as regards those thirteen stars known in antiquity, that should be ascribed rather to the negligence of those men who, trusting too confidently in the [old] tables, marked the positions of these stars wrongly, than supposed to conceal any flaw in our design, which is drawn from the heavens themselves and not from charts. This anyone may suspect for himself.

I have also deliberately added, in the earlier chart, a marking of the Galaxy, or Milky Way, by means of certain points indicating the places where it passes across this constellation, so that it may be established in what part of its boundary this New Star stood. For no small support toward investigating the metaphysical manner of its creation accrues from this, as will become clear when I treat of these matters.

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Diagram. The first Cassiopeia star-chart [*figuratio*] — a coordinate map of the constellation. It is a large quadrilateral border (drawn slightly skewed/trapezoidal as printed) graduated along all four margins in degrees, giving longitude along the top and bottom edges and latitude along the left and right edges. Within the frame the 26 stars are plotted as star-glyphs, each accompanied by its serial number (the same numbering used in the second chart). A dotted curving line runs diagonally across the field from lower-left to upper-right, marking the course of the Milky Way [Galaxia / via Lactea] through the constellation. The New Star is the large radiant star-burst near the right-center, labelled **NOVA**.

Marginal graduations (degrees, as read along the borders):

- Top edge (longitude): 30, 40, 45, 50, 55 [increasing left to right; the figure is slewed; the 30→40 interval carries tick-marks but no inked numeral]
- Right edge (latitude): 5, 10, 15, 20 [increasing downward], with an uncertain numeral [25?] at the top-right corner
- Bottom edge (longitude): 40, 45, 50, 55 [partly faint]
- Left edge (latitude): 5, 10, 15, 20 [increasing downward], with uncertain small numerals [~35? / 30? / 25?] stacked at the upper corner

Plotted stars with their serial numbers (positions approximate, top-to-bottom, left-to-right):

- 25 (upper left) — star-glyph
- 24 (upper left, right of 25) — star-glyph
- 23 (left of center, below 24) — star-glyph
- 10 (upper right area) — star-glyph
- 13 (upper right) — star-glyph
- 14 (upper right, right of 13) — star-glyph
- 22 (center-top; small star, labelled near the "○22" / cathedra marking) — star-glyph [the "near the eleventh small star" reference point]
- 12 (right of center) — radiant star-glyph
- 2 (center) — radiant star-glyph
- 8 (center-left) — star-glyph
- 3 (center) — star-glyph
- 9 (center-left, below 8) — star-glyph
- 1 (center; plain numeral "1" below its star-glyph, beside the ○22 marking) — star-glyph
- 11 (center-right, beside NOVA) — star-glyph
- NOVA (center-right) — large radiant star-burst (the New Star)
- 4 (center, below 1) — radiant star-glyph
- 20 (center, on a horizontal grid line) — star-glyph
- 5 (center, below) — star-glyph
- 19 (center-left, below 5) — star-glyph
- 6 (lower center) — star-glyph
- [unnumbered small star, lower right of 6] — star-glyph
- 18 (lower right) — star-glyph
- 17 (lower right, right of 18) — star-glyph

- 16 (lower right) — star-glyph
- 7 (bottom center) — star-glyph

Diagram. The second Cassiopeia star-chart [*figuratio*] — the figurative woodcut. A seated female figure (Cassiopeia) enthroned in a chair, shown in profile facing left, the right arm raised, the left hand holding a frond/palm-branch (the "arundo," reed/sedge spray). The 26 stars are placed upon her body, drapery, and throne, each marked with its serial number and a star-glyph. The New Star is the large radiant star-burst at the right, beside the throne-back, labelled vertically **NOVA**. A boxed legend at the upper left lists each numbered star against its anatomical/positional location.

Legend (boxed, upper left — number, then position, verbatim Latin with translation): | No. | Latin (as printed) | Translation | |---|---|---| | 1 | In Capite | In the head | | 2 | In Pectore | In the breast | | 3 | In Cingulo | In the girdle (belt) | | 4 | Quæ ad Ilia | The one at the flanks (loins) | | 5 | In Poplite | In the back of the knee (ham) | | 6 | In Crure | In the leg (shin) | | 7 | Extrema pedis | At the tip of the foot | | 8 | In flexura Brachij | At the bend of the arm (elbow-bend) | | 9 | In Cubito eiusd. | In the elbow of the same [arm] | | 10 | In altero Cubito | In the other elbow | | 11 | In Ereptione sedis | In the upright of the seat (chair-back) | | 12 | In medio Cathed. | In the middle of the chair (cathedra) | | 13 | In supremis. Sed. | At the top of the seat | | 14 | In extre. Sellæ | At the extremity of the chair (sella) | | 15 | Superior Scabelli | Upper [part] of the footstool (scabellum) | | 16 | Extrema Scabelli | Extremity of the footstool | | 17 | Media Scabelli | Middle of the footstool | | 18 | Sequens in scabel. | The following [star] in the footstool | | 19 | Præced. in Tibia | The preceding [star] in the shin | | 20 | Mola Genu | The kneecap (millstone of the knee) | | 21 | In umbilico | At the navel | | 22 | Paruul. ad crines | The little one at the hair | | 23 | Infer: Arundinis | Lower [star] of the reed (frond) | | 24 | Sequens in arun. | The following [star] in the reed | | 25 | Tertia Arund. | The third [star] of the reed | | 26 | Suprema Arund. | The topmost [star] of the reed |

Star placements on the figure (number — body/throne location, top-to-bottom):

- 26, 25, 24, 23 — ascending along the reed/frond held in the figure's hand (upper left)
- 22 — at the hair, beside the face
- 10 — at the raised right arm / elbow (upper right)
- 8 — at the bend of the left arm (elbow-bend)
- 2 — at the breast

- 1 — at the head (near crown)
- 11 — on the upright of the chair-back, beside NOVA
- NOVA — large radiant star-burst at the right, beside the throne (labelled vertically)
- 21 — at the navel
- 20 — at the kneecap
- 4 — at the flank/loin (lower body)
- 3 — at the girdle
- 19 — at the shin (lower left leg)
- 5 — at the back of the knee
- 9 — at the elbow (lower left)
- 6 — at the leg/shin (lower)
- 7 — at the tip of the foot (lower left)
- 18, 17, 16 — on the footstool/dais (lower right)
- 15 — on the footstool

In the lower-right corner of the frame is the engraver's monogram (a ligatured device).

I have so far recounted certain general matters concerning the time, position, form, magnitude, color, and other such attributes of this unusual and portentous phenomenon, and at the same time I have set out the constellation Cassiopeia together with the placement of this foreign star within it. In the chapters that follow I shall, as I deserve to, unfold more subtly and in greater detail the things that rightly come up for mathematical examination and demonstration concerning the study of this star.

That a New Star should have blazed forth — one that had never before appeared from the very beginnings of the world, that persisted in the same place of the heavens for more than a full year, and that finally, by degrees, vanished — is a miracle greater than the expectation and comprehension of all men. And among the things that have existed in the whole of nature since the primeval origin of the world, and that have been handed down in writing as marvelous spectacles, it is to be reckoned, if not the greatest, then at least the equal of those: of that wonder worked in the staying of the Sun's course in the time of Joshua [Iosue]; and of the retraction of that same [Sun] shown by the shadow-clock [gnomon scioterici] erected by King Ahaz [Achas], when Hezekiah [Ezechias], King of Judah, lay sick; or again of the obscuration of the Sun's light occurring on that day and at those hours when our Savior, Christ the Son of God, offered himself upon

the Altar of the Cross as a Victim to the eternal Father for the redemption of the human race. For the Sun then hid its face, begrudging its light and rays to the earth — as though [unwilling] to look upon him through whom all things, the Sun itself and the remaining bodies of the whole universe, both celestial and terrestrial, had been made; [unwilling to see] that he, made man, should for the sake of the human race undergo an ignominious death, a thing so unworthy — and so, out of compassion and shame, it veiled its face.

There is no doubt that this eclipse of the Sun occurred near the time of the full Moon, when the Jewish Passover was being celebrated. But at such a time the Sun cannot naturally be darkened, since the Moon, standing only a little away from the Sun's diameter, cannot withdraw it from our sight. Who, then, even slightly versed in the knowledge of the heavens, could fail to know that this is impossible? For this reason Dionysius the Areopagite, witnessing at Athens this eclipse of the Sun, so miraculous beyond measure, cried out that either the Author of the world was suffering, or that the world-machine was about to be dissolved — as he himself attests in his letter to Polycarp.

To such astonishing portents (I say), and to those miraculous works beyond the customary order of Nature, which the Sacred Oracles testify once came to pass from heaven, I judge that this New Star, which arose in our own age in the ethereal world, must be compared. For it truly was there, as I shall demonstrate so conclusively below that no room is left for objection.

For in the highest region of the celestial world, that some star similar to the rest — indeed, at times brighter and more glittering than the others — should newly and suddenly arise, stand fixed for a long time, and remain unmoved, is no less a marvel than for the Sun to stand still in the universal motion, or to move backward, or to suffer an eclipse without the Moon. Indeed, that something which did not exist before should unexpectedly appear in the heavens, an equal to the rest of its luminous bodies, is just as unusual as for those very lights which were set there from the first beginning of things to be affected contrary to their accustomed and constant course.

For who among the philosophers would deny that all the stars of the ethereal region retain the same position, number, magnitude, and form which they have held perpetually from the beginning, and that none of them either grows or even diminishes?

— or diminishes. (For as to what they maintain, that the seventh of the Pleiades was brighter than the rest before the destruction of Troy, and then disappeared, I

consider this to be poetic and fabulous.) For the longest experience of many ages has taught that the heaven, with all its bodies, remains subject to no change from the first Creation onward.

It is true that Aristotle [Aristotle], the monarch of the Peripatetic school, built his case on this principle — that the heaven receives no new bodies, being subject neither to generation nor to corruption (which is indeed true in itself and by nature) — and for this reason held it necessary, and labored to persuade us, that comets occupy a place not in the ethereal region of the world but far below the Moon, in the elemental seat of the air. Yet that the matter stands far otherwise, and that comets too are generated within the enclosure of the heavens, I shall demonstrate geometrically in the following books, from sound observations and beyond all dispute. Nor does it therefore follow that the appearance of the Star (of which we now treat) carries no more privilege than ordinary comets, or that it is to be equated with them; for this celestial body differed greatly from comets, since in its very form it wholly resembled the other stars, with no tail spread out in any direction, and likewise in its unmoved position and perpetual scintillation.

And although Aristotle says that the Egyptians observed certain tails clinging at times even to the planets, and that they noticed the same thing in the star at the Thighs of the Sign of the Twins [recte: at the Hips of Syria? — Latin reads "in Stella ad Coxas Syrii"] [?], and although Pliny [Pliny the Elder] agrees with him on this point in *Natural History* II.25 [*Naturalis Historia* Lib. 2, Cap. 25], saying as follows: "Sometimes tails are scattered even among the wandering stars, and other comets" — nevertheless it was permitted to no one to discern by any keenness of sight that anything of this kind was present in our star. But if anyone, to account for these invisible tails, should plead the star's excessive distance from us, he is using a deceptive conjecture rather than evidently proving that the matter stands so.

Nor, again, was this Star ever in opposition to the Sun, such that it might have rendered any tail it possessed invisible by turning it upward, away from view. For careful experience has now established in the great majority of cases that the tails of all comets are directed away from the Sun, as nearly as possible in a straight line. Likewise in its duration, by which it surpassed the lifetime of all the comets seen up to now, it shows that it received something peculiar to itself, distinct from comets. For this body exceeded by almost a whole year the longest term during which comets are wont to last [recte: the longest term comets usually last].

Altogether, then, this New Star surpassed the properties and nature of comets by many leagues [parasangis], and earned far more wonder and admiration.

Moreover, in no monuments of letters that can be trusted beyond doubt is it recorded that any New Star comparable to the rest had shone forth before — with the single exception of that one which Pliny, a writer not everywhere unreliable, mentions in Book 2 of the *Natural History*, at the beginning of chapter 6 [*Naturalis Historia* Lib. 2, init. cap. 6]; where he relates that Hipparchus [Hipparchus] observed another star, arisen in his own age, different from those before. And since Pliny's own words on this matter are, as elsewhere, distinguished and magnificent, I am pleased to set them down here, that they may be before our eyes; for he speaks thus:

This same Hipparchus, never sufficiently praised — than whom no one has more fully confirmed the kinship of the stars with man, and that our souls are a part of heaven — discovered a New Star, another one born in his own age, and from its motion,

and from the day on which it shone, he was led to doubt whether this might happen more often, and whether those stars too which we suppose to be fixed might be moving. And, in an enterprise bold even toward God, he ventured to number the stars for posterity, and to mark off the heavenly bodies by rule. By instruments he devised, he marked the places and magnitudes of the individual stars, so that from this it might easily be discerned not only whether they perished and were born, but also whether they grew or diminished — heaven being left as an inheritance to all, should anyone be found who could grasp that reckoning. And so much concerning Hipparchus from Pliny.

Now Hipparchus lived around the end of the Greek monarchy, nearly two hundred years after the death of Alexander the Great [Alexander the Great], about 125 years before the birth of Christ, when the war which was called the Cimbric War was waged by the peoples of those regions in Italy and at Rome — under the consuls Gaius Caecilius and Gnaeus Papirius Carbo.

It is clear enough, plainly, from the words of Pliny which he records about this Hipparchus, that Hipparchus truly beheld some unusual star in his own age in the very heaven; though it did not have everything in common with our star, for it does not follow that it was wholly unmoving in the manner of the fixed stars. This is evident from the fact that Pliny says Hipparchus was led by its motion to doubt whether this could happen more often, and whether those stars which are reckoned to be fixed might also at one time or another wander here and there.

Yet it is gathered clearly enough that it was very similar to the inerrant stars, except that it had acquired some motion of its own — so much so that Hipparchus took this occasion to undertake that immense labor of recording the places of all the fixed stars. For he did not then know whether all the fixed stars unanimously preserve the same position, immovable by perpetual law,

they would have observed it — which is an indication that, before his time, the positions of the fixed stars had not been set out in any catalogue [Abacum] suitable and complete enough for the purpose.

I am well aware that some of Pliny's interpreters — men in other respects not unlearned — twist these words of Pliny to refer to some comet seen by Hipparchus. But what drove them to this was rather the Aristotelian doctrine and authority in which they had been schooled from boyhood — namely, that the heavens admit no new bodies, and that all comets are generated in the sublunar air — than any sense that this is the genuine interpretation of Pliny's words. They were afraid that the heavens would collapse if they granted that a New Star could arise there. And so they preferred to put forward views that are empty, and wholly foreign to Pliny's words, along with Aristotle, rather than to acquiesce in Hipparchus — that most faithful investigator of celestial things, who saw this with his own eyes and beyond doubt measured this alien star carefully with instruments (since for its sake he undertook so many observations of other stars, with tireless labour). They preferred to detract from a man beyond compare, and a man of truth — as is plain from his own astronomical records cited by Ptolemy [Tycho writes "Ptolemaeo"], a most diligent man — rather than to depart from the Stagirite's [Aristotle's] merely conjectural opinions in this matter.

And if nothing of the kind had been seen by Hipparchus, and committed to writing, what need would there have been for Pliny to fabricate this on purpose — when there were so many other quite splendid things at hand that he might have proclaimed in praise of so great a man? And what, I ask, did he report about him that was remarkable or singular, if he meant only to say that Hipparchus had seen some comet born in his own age — given that the generation of comets is not so very unusual, but rather it is established that they sometimes appear even to common folk, and are noted even by those untrained in mathematics? There is scarcely

any human age in which one or two, if not more, are not seen. Did Hipparchus then accomplish anything remarkable, and does Pliny so highly commend him, merely because he saw some comet in his own age? Was he really driven by such weighty and serious reasons that, on account of some hairy star [Crinitam

Stellam] — a thing that runs quickly across the sky and often returns in much the same way — he should take so great a burden upon his shoulders, like a second Atlas, as to consecrate to posterity, in instruments, all the stars contained in the eighth sphere [Octavo Orbe] that are in any way visible? No one before him, so far as is known, ever drained such a labour, more than Herculean. I say nothing of the fact that certain of Pliny's commentators do not shrink from asserting that Hipparchus discovered, from the comet he saw (for that is what they wrongly call that New Star), that the fixed stars [Affixarum Stellarum] do not keep the same positions they held some centuries before. For that is more ridiculous than to need refuting. Is the exceedingly slow and constant motion of the fixed stars — which is scarcely perceptible within a single human lifetime — really to be tracked down from some chance sighting of a comet, and from its wandering course (which is recognized only after the fact, very rarely runs uniform, and does not last so very long)? When not even from the planets themselves — coeval with the world, whose revolutions and motions have for the most part been thoroughly explored — does any such help come, except insofar as the bounds [Termini] of the fixed stars are delimited by way of the Sun through the Moon, or through the planet Venus, as we ourselves have done. Yet to do that is a far different undertaking than to prescribe laws of motion to the fixed stars from unstable comets, since these latter, together with the rest of the wandering bodies [reliquis Erraticis], are themselves rather to be examined and judged by means of the fixed, settled, and permanent positions of the fixed stars [Inerrantium].

These

These things I mention for this reason: that no one, in imitation of the interpreters — men in other respects outstanding — should take amiss Pliny's words, brought forward in praise of Hipparchus, as though they ought to be understood of some comet, and not of a star peculiar in its kind and exempt from the class of comets. For my own part I have no doubt at all that Hipparchus did indeed observe in his own times some New Star most like the rest, and quite distinct from the hairy stars [Crinitis]. Yet of what sort it was, and how it displayed itself in all its particular circumstances — since this was not handed down by Pliny, and the works of Hipparchus have long been sought in vain — nothing certain can be pronounced. That something of the kind, whether before Hipparchus or even after him, was seen in the heavens now 1700 years ago [Annis 1700], can scarcely be proved safely and surely from any histories. For the historians, being for the most part not steeped in the mathematical arts, and generally also wedded to Aristotelian philosophy, do not know how to distinguish between stars newly arisen (if this has ever happened elsewhere) and comets, or

even fiery torches of the air; and from this it comes about that they very often take the one for the other.

Nevertheless I would not altogether deny that it has happened more than once, since the world's founding, that some new star has appeared in the heavens themselves — whether motionless after the manner of the fixed stars, or wandering after the manner of the planets — even though this has not been committed to writing. For it can well be that the appearance of such foreign stars [Peregrinarum Stellarum] has not always been noticed by men, since very few are found whom the lofty study of celestial things touches. For unless such foreign stars are very great and conspicuous, they do not catch just anyone's eye; rather, amid so great an abundance and variety of other stars, they are then also, through the inattention of observers [considera-

-torum], easily passed over and neglected. And this, no doubt, would also have happened in the case of the very star we are now treating, had it not from the outset struck the beholder so very plainly and conspicuously beyond the rest. For when it had diminished to that smallness that it might be seen as like the other stars of Cassiopeia, or a little smaller, most people supposed it had altogether vanished, or that it was some one of the genuine stars of that same asterism. What then would have happened, if at its first beginnings it had not blazed forth beyond the rest?

It is therefore possible that foreign bodies do indeed sometimes come forth in the heavens, and again vanish — though this is not everywhere noticed, or recorded in writing. But since nothing certain on this matter has been handed down by earlier writers, I am unwilling to pronounce a judgment about things unascertained.

That star which appeared in the East to the Magi, at the time of Christ's infancy, under whose guidance they sought Judaea, to adore the newborn King, and concerning whom they inquired at Jerusalem — and then, instructed at last, they found him at Bethlehem, this star going before them and standing still above the very house in which he was; and they offered him gifts, gold, frankincense [Thus], and myrrh, as to a King, to God and to a Man (just as these things are clearly reported by Matthew the Evangelist) — that star, I say, was not of the class of the heavenly luminaries [Coelestium Astrorum], nor did it agree in any way with this New Star, of which mention is here made, nor with comets. It was rather a peculiar and wondrous work of God, by which he saw fit to show the Magi — Gentiles, and having only a very scanty knowledge of God (except insofar as they might infer the Author through his works from the book of the universe) — that

very thing which lay hidden from the Jews themselves, among whom Christ was being born; prefiguring thereby, no doubt, that the Gentiles would one day be brought to the knowledge of the Truth and

and so that you may win grace, while those reprobate and obstinate Jews are struck dumb. For that this was the Star of the Magi, far different from the others that shine in the aether — whether it was native or foreign [*indigena sive ascititia*] — is sufficiently proved by the following. It first appeared to them in the East, and although it went ahead of them as they made for Palestine (as Nicephorus [Nicephorus Callistus] reports), it nonetheless disappeared for a while afterward, so long as they were searching in vain for the King at Jerusalem. But once they had been told to make for Bethlehem, in accordance with the Oracles of the Prophets, and had set out from there at once, the same star appeared again and lit their way, until it came to a halt above the House in which the Eternal King — clothed in the form of a human infant — could be seen in visible form. There too it stopped, a welcome and unmistakable marker of the place they sought.

From all this it may readily be gathered that this Star had nothing in common with the others (of which we have spoken). For it did not move in the highest region of the air, much less in the heaven itself. Otherwise — having set out, as some hold, from the East — how could it have pointed out the route from Jerusalem toward Bethlehem, since it would have been far too distant from sight to do so? Still less could it have marked out the House in which the Savior was to be found, so precisely and ahead of all the other houses in that City, unless it had been turning very close by, in the nearest air. For the bodies that rest upon the loftiest aether obey the universal daily revolution, and they single out no one place on Earth more than another. Indeed, even in the highest air — where Aristotle [Aristotle] falsely taught that comets are generated — it had no fixed station. For this cannot be granted: that some definite place on Earth could be marked out from there, once that lofty air (as he would have it) had been carried round to keep pace with the heaven.

There were indeed some who did not hesitate to assert that this Star of the Magi was an apparent comet. Among them is Carda-

Cardanus [Gerolamo Cardano], who places this star at the Ascendant when Christ was born, as if it were one and the same with the star that the Evangelist says was seen by the Magi in the East. But on that point he, and the rest of his followers, have made their claims more impiously than with sound reason, however they may finally excuse themselves. As for the rest of what he inserted

into his astrological commentaries on this subject — I am ashamed even to mention it — I shall not bring it forward.

Moreover, this Star seemed to be for the Magi alone. (For the Jews did not see it, even as it passed through their own region; otherwise Herod [Herod] would not have inquired so carefully about its appearance and condition, since he could have learned the same thing from his own subjects.) Either God, by some singular dispensation, bestowed this Gift upon them and set this Star before them, so that under its guidance they might seek out his Son, now already incarnate; or else, endowed with some more recondite Knowledge, they perceived what was hidden from other mortals, by the benefit of a certain exceptional skill [Magia] specially granted to certain men in those regions — from which, indeed, they took the name of Magi. And it was fitting that this should happen rather through the sight of some star than by any other means, because these wiser Men of the East were the more intensely devoted to the contemplation of the stars; and from this they perceived much that was hidden from other mortals, so that they might be drawn the more quickly by something similar to what already moved them.

But what, and of what nature, this Star truly was, I do not think it has been given to Men to unravel — since it was outside all the laws of Nature, and was, beyond doubt, the immediate Work of God alone. Hence even the ancient Fathers hold that, under the form of a star, there was some Angel divinely appointed to show the Magi the way — a question I nonetheless leave undecided.

There were also some, in this age, who ventured to liken this unusual Star to the one that long ago appeared to the Magi — whether in earnest, or by way of a jest of wit, I would not say — and who supposed that it foretold the Second Coming of Christ, just as that other star foretold the First. Foremost among them is Theodore Beza [Théodore de Bèze], a man of considerable renown, distinguished not only by Birth but, above all, by Learning, and outstandingly meritorious in letters both Sacred and Philosophical (if anyone in this age has been), who toyed with the subject of this Star in an elegant Epigram, thus:

This new one — a Comet with no fury in its hair, and shining with a pure flame, whose radiance gleams.

What it may portend to the lands, that God, the God of gods, knows, and will reveal his Decrees in his own Time.

But if human minds can foreknow anything of such matters, to probe them is not forbidden to me — nor are the Signs.

This is that very one which long ago, to David's [David] little Town, led from the East the Magi who once had been in the world before.

And the same star that lit the way for the newborn now announces:

"Behold, brought back, that God returns once more."

To him, then, O happy throng of the pious, give your applause; but you, bloodthirsty Herod, take fright.

In this manner that Distinguished Man sang in verse of this Star. Yet I do not think he meant in earnest that this was the very Star that lit the Magi's way; rather, he composed the piece thus with a certain Poetic playfulness. For in that he calls it a Comet, he admits something beyond the properties of a Star — as is clear from what we said earlier, and as he himself confesses, when he grants that it had no hair but shone forth with pure rays. And so he also likens it to the Star that guided the Magi, which appeared in no form of a comet. So too that point — that this Star was a Forerunner [Prodromus] of the returning Christ, just as the other foreshadowed his first Coming — is more piously conjectured than that it can be established either from Sacred Scripture or otherwise from some Philosophical

foreknowledge that this Star could signify the last coming of Christ and the dissolution of the universe of things. For among the Signs that Christ himself foretells will precede the world's end, no new Bodies of Stars produced from Heaven are reckoned — but rather those same bodies that have existed since the world's beginning will be consumed and will perish, and the Sun and Moon will be deprived of their Light.

And here I cannot refrain from noting, in passing, that those who interpret the Oracles of Christ about Eclipses — eclipses occurring every year in accordance with the laws of Nature and of the celestial motions — wander very far from his meaning. For his Prophecy proceeds not from the Light of Nature, but from the Secrets of Divinity. If those teachers of Scripture, so ready and so quick to cite the Book of Nature in place of the Bible's Codex in expounding this passage, would only understand it, they would see that, from the founding of the World, six eclipses occur every year in the Sun and Moon, by reason of the different Horizons — and so they would not, with such incompetence, pervert into a miraculous Prediction of Christ what happens of necessity by natural Law. Christ speaks of the Sun losing its Light — which the Moon, placed between it and us, will never take from it except as far as we are concerned. And such an obscuring of the Sun, beyond all doubt, is predicted by him to precede the last day: just as in his Passion, too, an obscuring was seen against all the order of Nature, one which

could be predicted by none of the Astronomers. And when the Sun is robbed of its Light, it follows that the Moon too is rendered dark, since it shines not with its own splendor but with the Sun's. Wrongly, therefore, do most men expound the Mystical Prophecy of Christ in a natural sense — men who, while professing to be masters of interpreting his words, are eager to win over the common crowd.

Indeed, they make their pronouncements about the consummation of the stars far too timidly. Or they speak of meteors [Facibus], the kind that subsequently fall on a clear night when dryness sets in or the winds are violent — claiming that such things will appear more frequently before the world's destruction. Or else they explain the matter allegorically, as referring to the failure and lapse of the lights of the Church (as these are reckoned to be); and on this latter interpretation it is, as regards the allegorical sense, not entirely inapt. For in Psalm 19 too the heralds of the Gospel are likened to the Sun and to the heavenly bodies. Therefore the Apostle's well-known words about heaven and the Sun, spoken literally and as it were by way of example, are with good reason applied mystically to the universal promulgation of the Gospel. But the earlier interpretation — the one that refers them to falling meteors, whose matter is sometimes even found on the ground — is utterly absurd, and altogether foreign to the mind of Christ. For that the heavenly stars too can at last be consumed, this very recent one, of which we are speaking, has served as proof: from the beginning it lacked no majesty of light and brilliance in its composition, so that one would say it far surpassed the rest of the fixed stars — and yet a year later it ceased to exist. In the same way all the others, however much from the first beginnings of the world they have been subject to no change, will be most easily dissolved whenever it shall please their Maker.

I have added these remarks for this reason: so that no one, on account of the ingenious speculations of certain people, should suppose that this New Star, seen in our own age, was the same as, or similar to, the one that appeared to people farther to the East; and so that no one should think that any certainty about the universal destruction of things lies open to divination from this; and that what is foretold elsewhere in Holy Scripture about the failure of the luminaries and the stars is, in the common explanation, less aptly accounted for.

But suppose someone were to draw the following inference about this New Star. Just as that Star of the Magi, in particular, pointed out to a few men a single House, in which Christ was being born at his first Coming — looming near, close over the earth — so this Star, set in the highest Ether, universally precedes, for all who dwell throughout the whole World, his second presentation in Majesty: that

one might find this a sufficiently plausible conjecture in this matter, I would not deny. But whether it is in fact true is known to God alone, in whose hand are the Times of the World and its age, things wholly removed from our knowledge. But where am I being carried away to? For it was no part of our undertaking to investigate these theological questions. So let what has been said about the Star that preceded the Magi — since it does not belong here — be enough.

In the same way I am of the opinion, and not far from the truth, that the Torch shaped like a Sword, which foretold the destruction of Jerusalem and stood for an entire Year over the City, was not a Comet (although Josephus [Ioseph] so calls it) — much less that it was any Star more excellent than the ordinary Comets. For it was fitting that this fiery Portent, which threatened the City, should not have been far removed from the zenith of the City of Jerusalem; otherwise it would have indicated some other place no more than this one, some other part of Judaea, or — if it were in the heaven, or even (as the Peripatetics hold) in the uppermost Air — revolved by the daily motion in the manner of the other Comets: in that case too, by its very great distance, it would in no way have marked out one particular and unique place upon the Earth. This portentous Torch lasted, moreover, beyond the customary period of Comets — for an entire Year, that is, on the testimony of the same Josephus. It was therefore something singular, ordained by God, as a Sign to forewarn the Citizens of Jerusalem of the dreadful disasters at hand, unless they should repent. Hence it took on a thoroughly prodi-

gious Nature as well, far exempt from the conditions of the Stars and the Comets — a point I leave to others for further examination and judgment.

Some Historians relate that in the time of the Emperor Hadrian [Adriani] a strange Star appeared in the Heaven. But whether this was actually so — since not all agree on the matter, and since it is reported very meagerly by only a few, as though it were a fiction invented on the Emperor's account — I leave in doubt, and as less worthy of credence.

Cyprian Leovitius [Cyprianus Leovitius], a man of noble Bohemian birth, devoted with great labor to Astrology, and especially to the construction of Ephemerides and the Tables serving them, also records that, in the leaflets he published about this Star, he had found among Historians that in the time of the Emperor Otto I [Otto] of the Romans a similar Star was seen in almost the same place of the Heaven; but he does not state from which Historiographer he has this. Nor, in the Book he entitled *On the Great Conjunctions*, when he was treating such matters

expressly, does he make any mention of a Star of this kind around the time of Otto I.

He adds also that in the year 1264 a Great and Bright Star appeared in the northern part of the Heaven — where this one of ours appeared too, near the constellation Cassiopeia itself — likewise lacking any tail [crinibus], and devoid of proper motion. If this is indeed so, that Star surely bore no small correspondence with the one we are discussing here, both as to the same place in the Heaven and also as to its form and immobility.

But he noted that he had taken the description of this Phenomenon from a certain manuscript codex. I would not readily be-

lieve that he has palmed off these falsehoods on us as truths. For to what end would he do so? Yet one thing does raise a doubt: that Pontanus [Pontanus], Camerarius [Camerarius], and certain others place in this very Year a Comet of remarkable Magnitude, one lasting a quarter of a Year. But since Pontanus says that it stretched its Tail from the East all the way to mid-Heaven, it cannot be that very Star which Cyprianus writes shone forth without a tail in the North, near Cassiopeia. And yet some transfer the Comet that Camerarius and Pontanus mention to the following Year — so that the Star which Leovitius adduces appears to have been a different thing; and indeed nothing came closer to this one which we are now describing. And it would have been desirable that its Appearances had been more fully recorded in writing by a competent Astronomer.

Since, then, the examples of Wandering Stars shining out from the heavens are so few — whether because they appear very rarely, or because they are neglected through the ignorance and inattention of men — we shall content ourselves with this one, which we have seen with our own eyes and measured with our Instruments, and we shall labor to bring forward to the best of our ability its Appearances and whatever can be pronounced about it astronomically: lest so admirable a Sign of the Divine Majesty, displayed to a World drawing toward its evening, should be erased from the Minds of Men before it is known of what kind it was, in what position, and how great.

For the accounts of it published earlier by most writers, even if in some part they hold together reasonably well, nevertheless — with the authors' leave, that I may speak the truth — have not touched the whole matter to the point [acu] (as the saying goes). And this, as I judge, is partly because their Instruments were not skillfully wrought

they have been left without [a method] not liable to error, partly because they did not first apply the verified positions consonant with the heaven of the Sun and the fixed stars, and partly too because they had not previously made the practice of observing—and the proper method of carrying out the task—familiar to themselves beforehand.

Indeed, in my own early youth I too poured out some things about this very Star—more impulsively than deliberately or carefully composed. These writings, though as regards its ethereal position they were thoroughly consonant with the truth, and contained several things not foreign to its appearances, nevertheless were not in every respect worked out to an exact standard there, nor polished with the final file. (For they had not been drafted under that title with any thought that I had decided to publish them; rather, I was driven to it by the urging of friends at least.) Whatever there is of them now no longer satisfies me, and it is judged insufficient for the dignity of the subject proposed and for a deeper description of so great a Miracle.

Therefore those matters which, drawn from observations both my own and others', come up for mathematical consideration concerning this Star, we shall now weigh with a more mature judgment and (as we hope) by a more refined balance.

CHAPTER FOUR [CAPVT QVARTVM]

On the instruments and aids by whose help the phenomena of this remarkable Star were more thoroughly explored, and the observations of it obtained from the sky.

Since all reliable knowledge must be sought and begun from the external senses—as Aristotle, the standard-bearer of the Peripatetic Schools, comes to teach, and as he himself does not oppose—yet the senses themselves, especially the visual, which are most needed here, falter when something is too far removed from the eye. They cannot discern with sufficient sharpness the position, distance, and magnitude of a body to be sighted, unless they are aided by certain other supports and also assisted and confirmed by geometric and optical reasoning. For this reason it was not without cause that craftsmen devised various Instruments and Machines, elaborated by the geometrical rule with precision, by which they might mark down the appearances of the Stars more accurately, and—trusting in these as on a ladder—might mount up into the highest Aether by the aid of the keenness of vision and by geometrical apportionment. And in that endeavor,

even though not all attained what they hoped for, some nevertheless did not stray far from the mark they sought.

Therefore, intending to measure out exactly the position of this unusual Star as well, its distance from the Earth, and its true Magnitude—for I did not lay these things open by the broad and general indication of mere inspection, as I noted in the preceding Chapter; rather, for the mathematical and physical, or rather, if that be granted, the metaphysical contemplation of this Star, [more is needed]—Mechanical Instruments fashioned skillfully and well are entirely sufficient. I therefore had need of them. For without them, if anyone hopes to be able to define anything certain, whether in this matter or in the other Lights of the Heaven,

he calls in vain upon Fortune (as the saying goes).

In the Instruments themselves, however, a singular choice must be exercised (for they do not all keep in reserve what they promise at first appearance), and in making them solid, diligence is required, joined with equal care in handling them—greater perhaps than has hitherto been reckoned by most. For unless they also achieve a magnitude sufficient for distinguishing the individual scruples [minutes] of degrees, and stand firm of a material not liable to alteration by the Air, both oil and labor are wasted. This therefore must above all be seen to first: that they be as simple as possible, yet consist of no fewer necessary parts and requisites than are needed, and moreover that they be rendered thoroughly handy and ready for handling and for use.

And although in some years preceding I had myself devised not a few Machines of various kinds—astronomical, outstanding for their accuracy and for the convenience of observing—and had had them built with great labor and expense, nevertheless at that time, when this New Star presented itself to view about 18 years ago, I had none ready to hand except one or two. For I had only recently returned to my Fatherland from Germany, and those instruments which I had had made at Augsburg [Augusta Vindelicorum] while I stayed there for some while, and had used, I had left behind there on departing, since they could not be carried here on account of their excessive bulk. The Astronomical Radius [radius astronomicus] I was indeed always able to have at hand, since it was easily portable; but since long Experience had warned me that it was not to be trusted too safely in the careful measuring out of the distances of Stars—especially where rather larger intervals were to be examined—therefore as soon as

possible, my travels completed, once I had given myself a little rest in my Fatherland, I straightway ordered another Instrument to be made for taking the distances of the Stars, to which this delicate task might be entrusted more reliably than to the Radius; and I had it made on the model of the one which, on leaving Augsburg, I had given to the Consul of that City, a man most devoted to Astronomical matters, PAULO HAINZELIO [Paul Hainzel]—but somewhat larger and more perfect.

And it happened conveniently that, when this Star unexpectedly shone forth unaccustomed, that Instrument was finished and already brought to its final polish, so that by its mediation the appearances of this Star could be measured.

Now it was simple in itself, and not entangled by many complications; for which reason too it dispatched the whole business more surely and safely. For it consisted at least of two Rules joined to each other below by a certain round Pin, so that around this the Angle of the Instrument could be opened out and again drawn together. At the far end, with a certain Arc representing a sixth part of the Circle fastened to one of them, the rest [of the arc] ran along the Circumference of the same, here and there. The drawing-apart and the contracting of both Rules, as the distance of the Stars to be observed required, was managed by a certain Screw [cochlea] [set] from the Center of the Instrument—[at the point] where, according to where the eye of the Observer was placed, set within the Sights [pinnacidia] at the end of the Rules, it could sight the intervals of the Stars. And it was distant [from the center] just so far as the length of the arm required, so that the Screw could be turned by hand while the eye meanwhile remained near the Center, unmoved.

But so that all the parts of this Instrument, its Composition, and its Use may be grasped more readily, I shall present its picture for viewing; from which everything will be understood more easily than from a copious recollection of words. Expl[anation...]

Diagram. A full-page woodcut of Tycho's astronomical sextant. The instrument has the form of a narrow triangle (a wedge), point downward, with a graduated arc spanning its open top. The two long straight arms (the rulers, *regulae*) run down from the ends of the arc and meet at a pivot at the bottom; the upper arc, the lower bracing arc, and a threaded screw-bar across the middle are all labelled. The page bears the running header at top.

- B (upper left, head of the left arm): mount/sight-vane fitting at the left end of the graduated arc

- C (upper right, head of the right arm): mount/sight-vane fitting at the right end of the graduated arc
- The graduated arc (between B and C) is divided and numbered along its scale: 5, 10, 15, 20, 25, 30 — degree divisions running from the left end toward the right
- K (just below and right of C): fitting at the outer right of the arc
- D (mid-left, on the left arm): position of a pinnule / sight aperture on the left ruler [the two small circles drawn beside D are the sight-holes]
- F (left of D): a small knob / catch at D (the locking piece beside the left pinnule)
- E (mid-right, right end of the cross screw-bar): outer end of the long threaded screw [the screw labelled D E running across the instrument]
- M (center-right, where the screw-bar crosses the right arm): the nut / traveling block on the screw, riding on the right ruler
- L (below M, on the right arm): point on the right ruler at the lower bracing arc
- G (below D, left end of the lower bracing arc): left foot of the small lower arc on the left ruler [the arc G L H]
- H (lower right, free curved end): the end of the curved handle/brace projecting to the lower right [the arc continues past L to H]
- A (in the diamond at the foot, within the pivot disk): the central pivot about which the two rulers turn
- O (just below A, in the same diamond/disk): the center mark of the pivot disk
- I (directly below the pivot disk): the lower point where the two rulers join at the pivot mount

Explanation and Use of the Preceding Instrument

[Explicatio atque usus antecedentis Instrumenti]

I named this instrument the Astronomical Sextant [Sextans Astronomicus], because its circumference takes in a sixth part of a circle — although I have sometimes fitted it with an arc spanning only a twelfth part, or the interval of a single zodiacal sign. I kept on hand various arcs that could be attached to it with little trouble, according to what the distance between the stars required. Large arcs gave more difficulty in handling the instrument than smaller ones, and so I did not willingly use the larger ones unless a wider separation of the heavenly bodies called for it.

The two rulers [regulae] were four-sided, four cubits long, three fingers wide, and two thick. I did not make them out of solid metal, since metal would then have been too heavy under its own weight and unwieldy to handle; instead they were prepared from walnut wood [ex ligno Arboris Iuglandum], thoroughly seasoned for many years. This wood has the special property of being as little subject as possible to changes in the air, and, once worked smooth and straight along its length with the plane, it does not readily take on any warping of its own. Where these two rulers were joined together at the center A, they were connected and reinforced with a metal pin, with a hole as well, and the whole assembly secured with little plates of brass [laminulis aeneis].

The arcs themselves, which carry the division into degrees and mark off the distances, were made of solid metal — that is, of brass worked exactly true and drawn out by hammering into the curved shape — so that they would resist any violent warping more steadily, and would spring back of their own accord into their proper form whenever by some accident they suffered any strain. There were pinnules [Pinnacidia] of brass as well,

of the kind shown at B and C, likewise fitted to the rulers so that on the inside their edge corresponded exactly to the inner surface of the rulers, and together with the upper one they stood at right angles to it. For in this way the instrument measured the space contained between the two pinnules, intercepting the arc of the rulers as it was extended. The degrees, marked off on the arc itself with an exact and finely cut division, were of such ample size that an interval of a degree and a half [sesquialterius digiti — i.e. one and a half digits of width corresponded to a degree] would be spanned, and they were therefore sufficient for distinguishing the individual minutes separately. For I had not yet devised that compendious division of the degrees by which, through transversal points, they are more conveniently and readily distributed into the smallest little portions; nor had I devised the parallel slits [rimulas Parallelas] by which a star can be sighted in the same way from either side of the pinnule with the least trouble. In taking altitudes, at least, I had fitted a single slit to the forward pinnule, as I shall point out later when I come to treat of these matters.

I also employed a certain other small arc, G L H, which was fixed on the first ruler at G and ran across the other at L, standing off from the center at about a third of the length of the rulers. This served a double purpose: partly so that, as the rulers of the instrument were moved this way and that, it would hold them more truly in the same plane — yet without all the weight of a brass arc set close to the pinnules adding to the load; and partly so that, by means of a small screw

[Cochlea] set on the other side below L, with this arc intervening, the arrangement of the rulers might be held more firmly fixed once the interval between a pair of stars had been obtained with sufficient precision. It is also permitted, for the same use and for surer stability, alongside the pinnule C,

to set on the other side of the ruler a similar screw, by which, once the observation was finished and the instrument set down away from the eye, the position of the movable ruler could be held firmly fixed on the arc of divisions. But so that this instrument could be more conveniently drawn apart and clamped together, until the interval of the stars to be measured was exactly grasped by both pinnules, I had another, elongated screw [Cochlea oblonga], D M E, fitted to it as well — likewise on the rear part of the instrument — which, turned this way or that through the handle properly shaped at F, would draw the rulers of the instrument together toward one side or the other, or else release them, according to what the observation of the interval required. For it could not be drawn out farther from the center of the instrument than would allow it to be worked, with the eye held steady at I, by governing the screw's handle with the left hand. Now, although this screw was straight and not curved like an arc — so that it might seem remarkable how it could govern rulers that were moved about the center in the manner of an arc — nevertheless, to guard against this obstacle, I had fixed the rear nut-blocks [Matriculas posteriores], in which the screw turned on its thread, onto little rounded, freely revolving pins; and so, whatever the manner of extension the screw demanded as it was turned about, in order that the rulers should be driven in their arc-like motion, those movable nut-blocks complied by tilting one way and the other.

And so, with the eye applied at I — and there too, when the work was to be carried out by sighting more accurately, with a certain little slit added, so that in the dark the eye should not stray at all from its place, set opposite the center of the instrument with respect to the circumference — the surface of the whole instrument was directed into the plane of whichever two stars were to be measured through their interval; and by moving the elongated screw D E this way and that, through the action of the handle at F,

toward F, until that star was sighted within the sights B and C so exactly that nothing was either in excess or deficient. Then at last the little screw was tightened at the back near L, and—if one wished—the other one as well, which from the rear part below the sight was set against the arc of the instrument near K. However many degrees and minutes lay between the sights B and C, by that same amount the proposed star was indicated to have moved. And so, by

loosening the smaller screws twice or three times and changing the angle of the instrument, a test was made of whether the same interval came out precisely the same everywhere, and this was repeated until all the readings agreed exactly with one another.

But because the pupil of the eye could not be set at the center of the instrument—the center with respect to which its arc and its divisions are laid out—being prevented by that solid part which runs from A to I, it therefore turned out to be necessary that the distances, viewed with the eye placed eccentrically beyond the midpoint of the arc, should appear somewhat larger than the truth and not entirely in agreement with the heavens themselves. So, in order to remedy this difficulty, I kept a certain little table noted on the rear part of the instrument. This table showed the parallax of the instrument—that is, how much, for each individual degree of the observed separation of the stars, had to be subtracted from the apparent distance so that it would come out true and consistent with the heavens themselves, as if the sighting had issued from the center of the instrument. And in this way, by a small shortcut, I made good this shortfall. The method by which these parallaxes and their table were derived is as follows.

Imagine, in the next following figure, that A is the center of the instrument; let A B and A C be both of its rulers, and let the eye of the sighter be next to I. Ruler B A is always in a straight line with the inner surface of the ruler; and therefore from that side it produces no parallax, since ruler B A is at rest while the other ruler A C is moving toward and away from it.

Diagram. A narrow, elongated isosceles wedge (a circular sector with a very small central angle), representing the two rulers of the sextant converging at the eye. The wide arc at the top runs between the two upper vertices B (left) and C (right); the two long sides converge downward. Near the bottom the vertex A is marked just above the lowest point I, with two nearly-coincident lines running down to I—representing the solid central part of the instrument between A and I and the eye placed at I.

- B (upper-left vertex): one end of the arc / the far sight
- C (upper-right vertex): the other end of the arc / the near sight
- A (lower vertex, just above I): the center of the instrument
- I (lowest point): the position of the eye of the sighter

toward and away from it, by this other ruler A C. Therefore let B A be produced to I, and from I—the eye—let a straight line I C be drawn to C, toward the other sight, along whose line the line of sight passes to the sight C. I claim that the angle

A C I is the very parallax of the instrument, which is found as follows. Since the angle B A C is known once the observation has been completed, by means of the arc B C, its exterior angle C A I is thereby given—namely the complement to two right angles. Hence in the triangle A C I, since two sides together with the angle they enclose are given—C A being the very length of the ruler from the center to the sight, which can be subdivided into a number of parts, say thousandths, and it is then to be seen how many of those little parts make up A I, for A I will then be given in those same parts—it consequently follows from the laws of plane triangles that the angle A C I is laid open. This angle, manifesting the parallax sought in that apparent separation of the stars, is always to be subtracted from the true interval, because the eye, placed at I, takes in a larger arc B C in viewing the two stars than if it were at A, the midpoint of the arc itself. And so, for each individual degree of the whole sextant, a table presenting the variation of the instrument's aspect was drawn up; nor is there even from one degree to the next any great difference of parallax. And if one wished to carry out the matter quite scrupulously, this little difference was limited proportionally.

And in this manner we corrected that aberration whereby the eye was not set at the center of the instrument, so that this instrument might yield intervals far more exact and well-assured than the astronomical radius [radius astronomicus].

Nevertheless I noticed, in some of the following years—after I had had a good many more and various instruments constructed, in particular by the benefit of the trigonic sextants [sextantes trigonici], an idea of which I set out in an earlier chapter—that the distances of the stars taken with this instrument turned out to be a few minutes larger than was right. This appeared when I observed those same pairs of stars—whether of Cassiopeia or of another asterism—through each instrument, both that old one and the new sextant, which is subject to no parallax. I detected the cause of this slight deviation clearly enough: it lay in the fact that the cheekbone of the face, right below the eye, was at least applied to the instrument near I, and not the pupil of the eye itself, from which the visual ray chiefly proceeds. The little space, then, from the pupil—that is, the center of vision—to I, the beginning of the instrument, was still introducing some small parallax, which somewhat increased the earlier parallax that arose from the instrument itself on account of the magnitude of the line A I. And so the parallax subtracted on account of the instrument came out larger than was supposed, and consequently the distances themselves came out a tiny bit smaller.

The intervals of the New Star [Nova Stella] from nine of the principal stars of Cassiopeia, however—carefully sought out and, on account of the aforementioned

cautions, duly limited, namely insofar as the remaining trigonic sextants, subject to no ambiguity, supplied them, an experiment carefully set up upon stars having a roughly comparable remoteness—I will now present.

The distances of the New Star from certain principal fixed stars in the asterism of Cassiopeia, diligently explored and verified.

	Names of the stars [Nomina Stellarum]	G. (degrees)	M. (minutes)
1	the Head of Cassiopeia [Capite Cassiopeæ]	10	22
2	Schedir [Schedir]	7	50½
3	the Girdle [Cingulo]	6	53
4	the Bend [Flexura]	5	2
5	the Knee [Poplite]	8	3½
6	the Leg [Crure]	9	48
7	the Tip of the Foot [Extrema pedis]	12	58½
1	the Upright of the Seat [Erectione Sedis]	1	31
1	the Bright Star of the Throne [Lucida Cathedræ]	5	19

The left-hand brace is labelled **The New Star was distant from** [Nova Stella removebatur à].

These, I say, were the distances of this unusual star from those bodies coeval with the world nearest to it—exactly noted and several times rechecked on a fair balance—so much so that I have no doubt they are so accurate and precise that not even a scruple's worth of deviation, or beyond, lies hidden in them. To what extent others, by a few scruples—some more, some less—have departed here will be shown in its proper place, once the due comparison has been made.

I have also rather often examined the interval of the New Star from the Pole Star [Stella Polari], p. 25, l. 14, and I have no hesitation at all that this too holds good to a hair's breadth; and it will be of no small use to us in investigating the inmost secrets of this star.

Moreover, I have accurately observed the mutual separations of several of the stars in the constellation of Cassiopeia itself, and also of some of them from the Cynosure [Cynosura, the Little Bear], partly with that same old instrument, partly and chiefly with other, more recent trigonic sextants; and these I will set out for the eyes all together.

The distances of the principal stars of Cassiopeia from one another

[This page continues the table of mutual distances among the chief stars of Cassiopeia. Each block gives, for one reference star (named in the left-hand brace), its distances to the other numbered stars. Columns: the star's serial number, its name/position, degrees (P.), and minutes (M.).]

The star that is in the middle of the Chair, the bright one [*Quae est in medio Cathedrae Lucida*], numbered 12, is distant from it:

No.	Star [Nomina Stellarum]	P. (deg.)	M. (min.)
1	In the head [In Capite]	6	33½
2	In the breast [In Pectore]	4	59
3	In the girdle [In Cingulo]	5	19
4	The one at the flank [<i>Quae ad Ilia</i>]	6	12½
5	In the knee [In Poplite]	9	42
6	In the leg [In Crure]	13	17½
7	At the tip of the foot [Extrema pedis]	17	26
11	In the upright of the seat [In erectione sedis]	4	44

The one in the breast [*Quae in Pectore*], called Schedir, numbered 2, is removed from:

No.	Star	P.	M.
1	In the head [In Capite]	2	41
3	In the girdle [In Cingulo]	1	42
4	At the bend [Flexura]	4	40
5	In the knee [In Poplite]	6	56
6	In the leg [In Crure]	11	33
7	At the tip of the foot [Extrema pedis]	16	28

No.	Star	P.	M.
11	In the upright of the seat [In erectione Sellae]	6	27

The one at the flank next to the bend [*Quae est ad Ilia iuxta flexuram*], numbered 4, is distant from it:

No.	Star	P.	M.
1	In the head [In Capite]	7	20
3	In the girdle [In Cingulo]	3	3
5	In the knee [In Poplite]	3	35
6	In the leg [In Crure]	7	19
7	At the very tip of the foot [In pede extrema]	11	56½
11	In the upright of the seat [In erectione Sedis]	3	35

The one in the upright of the seat [*Quae in Erectione sedis*], numbered 11, is separated from:

No.	Star	P.	M.
1	In the head [In Capite]	9	3
3	In the girdle [In Cingulo]	5	23
5	In the knee [In Poplite]	6	48½
6	In the leg [In Crure]	9	9½
7	At the tip of the foot [Extrema pedis]	12	49

[This page continues the same set of mutual-distance tables, then gives a separate table of certain Cassiopeia stars from the Pole Star.]

No.	Star [Nomina Stellarum]	P. (deg.)	M. (min.)

The one that is in the head [*Quae est in Capite*], numbered 1, is distant from:

No.	Star	P.	M.
3	In the girdle [In Cingulo]	4	17
5	In the knee [In Poplite]	9	6
6	In the leg [In Crure]	13	53
7	At the tip of the foot [Extrema pedis]	18	54

The one that is in the girdle [*Quae est in Cingulo*], the third, is distant from:

No.	Star	P.	M.
5	In the knee [In Poplite]	5	19½
6	In the leg [In Crure]	9	53
7	At the very tip of the foot [Extrema pedis]	14	45

The one in the knee [*Quae in poplite*], numbered fifth, is distant from:

No.	Star	P.	M.
6	In the leg [In Crure]	4	50
7	At the tip of the foot [Extrema pedis]	9	56

The one in the leg [*Quae in crure*] is distant from:

No.	Star	P.	M.
6	At the extremity of the foot [Extremitate pedis]	5	9

The carefully-measured intervals of certain stars of Cassiopeia from the Pole Star [Cynosura]

[*Quarundam Stellarum Cassiopeae à Cynosura exquisitae intercapedines.*]

The Pole Star [*Stella Polaris*] is distant from:

No.	Star [Nomina Stellarum]	G. (deg.)	M. (min.)
2	In the breast [In Pectore]	32	48½
4	The one at the flank [<i>Quae ad Ilia</i>]	28	36
11	In the upright of the seat [In erectione sedis]	26	26
12	In the middle of the Chair [In med. Cathedrae]	30	13½

These, then, are the results that — as far as concerns the distances of the New Star from the other stars in Cassiopeia, and the distances of those stars from one another — I have thought worthwhile to work out for our purposes, both by means of this instrument and by the limiting procedure described, together with certain other methods I applied, in order to determine accurately the appearances of this unfamiliar star.

It should be understood, however, that this newcomer star [*Stella Neoterica*] kept exactly the same interval from the others no matter where in the whole motion it

was observed — whether above the Pole, or below it, or even at either side. So precisely was this the case that it was never possible to detect any difference at all, not even the slightest,

in any position whatsoever. The angle of the instrument was fixed again and again, and remained exactly the same throughout. Meanwhile, while the star stood now higher, near the zenith, and now lower, toward the horizon, the observation was repeated; and even so it showed this New Star separated from any other star by precisely the same amount, with no trace appearing of any greater or smaller interval. I scrutinized this most diligently a number of times, since the investigation of parallaxes — which is the matter of chief importance (and of which I shall treat later) — depends above all on this point. For it does not matter, in this respect, if the instrument were in error by a few minutes, since one and the same angle remained throughout — an angle that there was no need even to count, however large it was. It is entirely sufficient that it stayed the same, so far as the disentangling of the parallaxes is concerned, of which I shall speak more fully in the following chapter.

And let these foregoing remarks suffice as regards the distances of the New Star from the other fixed stars, and of the fixed stars from one another.

I also took great pains to measure carefully its altitudes, especially the meridian ones, all at once; but no Quadrant was suitable, nor any other instrument properly assigned to this task ready at hand, by means of which I might obtain that altitude precisely enough. I therefore used this very instrument for its lower [*citima*] altitude, when it was positioned in the meridian below the Pole. For when it approached the zenith — its uppermost position — it was not possible, on account of the star's very great altitude at that time, to take it with this device, since the star then leaned back from the zenith of our heads [*Zenith Capitem*] by only about six degrees, whereas the largest arc I had fitted to the instrument filled out only a sixth part of a circle.

Diagram. A perspective woodcut of a large meridian altitude instrument (a sextant-arc / mural-type apparatus) mounted against a corner of a masonry observing chamber. At the upper left a tall arched brick wall niche carries a graduated vertical scale along its inner edge. The principal instrument is a long radial arm pivoting from an upper corner, carrying a graduated arc (a sixth-of-a-circle sextant arc), with a plumb-line and bob hanging below at the base. The instrument rests on a horizontal base-beam supported at the right on a turned stone column standing on a tiled (checkerboard) floor. The graduated arc near

the top bears the engraved degree numerals **60, 55, 50, 45, 40, 35, 30, 25, 20, 15** (read along the arc N→C, a regular 5° run over the 60° / sixth-of-a-circle arc).

Readable point-labels (positions as drawn):

- N (top): apex/sighting end of the upper radial arm, where the graduated arc terminates
- C (upper left): pivot corner of the radial arm at the top of the arc
- E (right, mid-upper): point on the dotted sight-line / a fixture on the right limb
- H (right): a bracket or sighting fixture at the right
- M, L, K (center-right, along the long arm): graduated divisions / fittings along the main arm toward I
- A (lower right, on the arm near I): fitting at the outer end of the arm
- 4 (lower right, arm end): boxed index numeral on the arm end, just outboard of the A fitting
- I (far lower right): outer terminus of the base-beam
- G (center, on base-beam): fitting on the horizontal base-beam
- O (center, on base-beam): point on the base-beam
- B (lower left, on base-beam): left terminus of the base-beam at the wall
- P, Q (center-lower, on base-beam): divisions on the base-beam
- R (left, on the lower arc): point on the lower (left) graduated arc
- D (center, below base-beam): plumb-line attachment
- F (center, below): point on the plumb-line
- S (center, below): the plumb-bob hanging at the bottom of the line
- T (center-right, on base-beam above column): fitting where the beam meets the column support
- V, X (lower center-right): base / footing labels near the column
- [Additional small numerals on the lower-left arc (e.g. near R): numeral: ?]

I will now explain by what method I obtained the minimum altitude of this star with the help of the same instrument.

I set up this sextant in the way shown in the diagram assigned to it: as regards the first rule A B, I placed its forward part in a certain high window, above a wall, so that this rule lay exactly along the celestial meridian. Toward the rear, near the center T, I set a certain support V X of the appropriate height, so that the rule itself corresponded precisely, by equilibrium, to the level of the horizon — something I could readily verify in this way.

Once the instrument's arc R N was directed to the plane of the meridian, and the plumb line N S had been hung at the end of the sixty-degree mark N, I would raise and lower the fundamental rule A B — and with it the whole instrument — by means of certain wedges placed inside T and V X, until the thread N, O, S, to which the lead weight was attached at S, struck exactly the midpoint between the center of the instrument at A and the circumference of its own graduated scale, namely at O. For it is evident that the base of the instrument, that is, the rule A B, was then precisely level with the horizon. Since, according to the *Elements of Geometry*, a sextant of a circle subtends from the center an equilateral triangle (as is a corollary from Euclid, Book 4, Proposition 15) [*Elements* IV.15], this triangle is represented by the markings R N A, and by the line of the rule R A. And since the straight line N, descending from the vertex of that triangle, bisects the base R A, this must necessarily occur at right angles, as is clear from Proposition 12 of Book 1 [*Elements* I.12] and from those immediately preceding it. Therefore, because the plumb line N S by nature always points toward the zenith, and because it is joined to N O, the rule R A will be entirely orthogonal to that same plumb line; and consequently it will also be at the level

of the horizon, from which the zenith is everywhere distant by a right angle, conformable to a quadrant of the circle.

With the instrument thus carefully arranged in this manner, I would wait until this New Star, in its declining position, reached the meridian through the universal motion [of the heavens]. Then, by means of another pinnule analogous to the first — placed near C corresponding to the other rule, not far from the center near R, set there so that it could be moved when use required — I would take my sighting. For in its upper part I had made a small slit, parallel (together with the upper side of the forward pinnule) to the lower part and to the center, through which, while sighting, I varied the angle of the instrument by means of the oblong screw O E, until the New Star was aligned precisely with the edge at C of the upper pinnule — half of the star projecting and the other half hidden, as far as any keenness of sight allowed me to discern (for I had not yet devised those slits parallel on both sides of the forward pinnule, by which stars are sighted upon their centers with the least trouble). And in this way, with the arc intercepted between both pinnules B C, the star displayed above the horizon that minimum elevation which I intended to observe.

But since it could happen, through some slight disturbance, that the rule B A — and with it the whole instrument — might be displaced from its exact arrangement, as regards the level of the horizon, in the course of the

observations (if perhaps the supports on which it rested, especially the rear one, should give way somewhat through the wedges driven beneath), I therefore had, on either side of the small line at O situated in the middle of the lower rule — the point which the plumb line, when the instrument's position is properly maintained, ought to touch — certain divisions, marked on a small arc P Q described about the center N, so that for the magnitude

of one degree, on the semidiameter of such a circle, the minutes might be distributed on either side. These were to be subtracted on the forward side O P, but added on the rear side O Q, according as the plumb line indicated some slight inclination from the level in one direction or the other. And so the altitude found by means of the arc B C, once the observation was completed and the plumb line inspected again, was verified — and, if need be, corrected.

The minimum altitude of the New Star, which I found and examined many times over, came out as follows:

The minimum altitude of the New Star, frequently explored.

27° 45'.

And since the elevation of the pole at Herrevad [Herritzwad], where for the most part I carried out my observations on this star, is 55° 58' — quite precisely, falling short by at least two scruples [seconds] of the full completion of 56 degrees — this star was distant from the celestial pole by 28° 13'.

Therefore its complement to a quadrant of the circle, that is, its declination, or minimum distance from the equator, was revealed in this way:

The declination of the New Star, ascertained from its minimum altitude.

61° 47'.

Now everything stated above concerning the observations of this star — both as regards the distances and the altitude and declination indicated thus far — remained perpetually in the same condition, and admitted no change whatever throughout the entire duration of the star; unless perhaps the declination, just as happens with the fixed stars, especially those situated near the equinoctial points,

may have been altered ever so slightly. Yet because of its extreme smallness — since it could scarcely amount to a third part of a minute — this was imperceptible, unless I had then had at hand instruments of the kind now available, by which it is possible to perceive exactly how far the declinations of the stars change from year to year. So much so that the Pole Star itself is found to

increase its declination annually by about a third part of a minute, and thus to approach nearer the pole.

In truth, however, since it is especially useful to take into account not merely the minimum altitude of this star, but also its maximum altitude near the zenith — and since I did not at that time have in use instruments large enough to measure stars at such a height, which would have been of the requisite magnitude (as I have said before) — I shall borrow certain observations made with the great quadrant near Augsburg [Augustam Vindelicorum], which was once built, at the desire of the most distinguished Paul Hainzel [Pauli Hainzelii], consul, to satisfy his wish. He himself carefully recorded these observations and afterward transmitted them here to me in Denmark, together with other things accomplished in the heavens with that same quadrant. For so we had agreed between ourselves when we were parting.

Nor is there any reason for anyone to interpret it unfavorably that I add to my own work observations obtained elsewhere. I regard those that were made with that quadrant as if they were my own, since it was chiefly for my sake and at my urging that the consul had that machine prepared — I myself prescribing and directing everything for the craftsmen, and distributing the divisions with my own hand — so that it is not inappropriate for all the observations obtained with its help in the heavens to be turned to my own use.

But before I report the altitudes observed with that quadrant, I will describe the structure and form of the instrument itself — which was enormous — and, so that it may be understood more readily, I will present a drawing of it; though first I will briefly indicate on what occasion it was built.

De Quadrante permagno, quem propè Augustam Vindelicorum olim construximus.

On the very large quadrant which we once built near Augsburg.

About twenty years ago, when I was staying for a time at Augsburg [Augustae Vindelicorum] — a city that surpasses the other towns of upper Germany in splendor, in the healthfulness of its air, and above all in its citizens, especially its patricians, who are remarkable for their singular courtesy and goodwill, and for the exceptional industry of their craftsmen and artisans — I was welcomed by very many of the leading men of that city, men preeminent in the antiquity of their family, in their rank, and in their wealth. And, what I think more

praiseworthy still, they had also devoted excellent and most diligent effort to the liberal disciplines. I formed a most agreeable friendship with them. But above all I did so with two brothers of the Hainzel [Hainzelii] family, of whom one, Johann Baptist [Johann Baptist Hainzel], held the distinguished office of one of the Seven Men [Septemviratus], while the other, called Paul [Paul Hainzel], was the city's consul for the year. Both had been splendidly educated in the humane letters, and both also took the greatest delight in the study of astronomy — particularly that most eminent and most learned man Paul Hainzel, who seemed devoted to this art with great intensity, drawn to it as if by some natural inclination.

Since, then, we kept visiting one another from time to time at our leisure, and discussing the studies that engaged us both, it happened that, while I was sketching and laying out the subdivisions of a certain instrument on paper — by which I might explore how great a capacity [capaci-]

[Margin / page number: 354]

—how great a capacity it would require in order to take in the marking-off of the individual minutes distinctly — he came to my lodging, and asked what I had in hand. Once I had explained the whole matter, and shown how great the quadrant I was designing would have to be, so that it might suffice for taking in the individual minutes by some small portion apiece, he at once urged me that we should undertake some such thing useful to the art, and eagerly accepted the proposal. Yet it seemed that he somewhat shrank from so vast a size as I was specifying, because it would require much labor and expense.

But I explained to him that, unless it were of so great a capacity, it would not easily distinguish the individual minutes — so that even some fraction of them could be marked off — and would therefore be less suitable for use, especially as regards observations of the Sun. (For at that time I had not yet learned of that transversal subdivision of the degrees; rather, I was distributing the degrees, in their order, into their minutes merely in the ordinary way.) I added too that no labor or expense should be spared on so outstanding a work, since far more of both is squandered, more uselessly, on the cheapest and most fleeting of things. These things I was proposing not as they had then casually entered my mind, unpremeditated, but as weighed by the deliberation of many years, ever since my boyhood. For long before I had recognized that those childish instruments [Organa] — the kind for the most part handled by the cultivators of astronomy in Germany — contribute absolutely nothing of help toward a sound and indubitable observation of the stars. And I myself had earlier built quadrants of three or four cubits from the center to the circumference; yet not even these,

especially with the ordinary method of subdivision employed, were equal to the precision which the [negoti-]

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—which the work required, so as to give satisfaction. Moreover, from my handling of the astronomical radius [Radius Astronomicus] — whose use had been familiar to me ever since my seventeenth year — I knew well enough that with those small and trifling instruments nothing excellent could be achieved, nothing that might serve substantially toward the restoration of the art. I was therefore wholly absorbed in this: that we should make an instrument either none at all, or else as large as possible. For I had resolved that this was something I ought by all means to do for myself, if ever I should be granted the leisure to settle in one place for a while — precisely because I saw that the very vastness of the instrument contributes most toward the scrupulous exactness of the subdivision, and toward the reliability of the observations, provided especially that the machine be well joined, and solidly and carefully wrought.

So he, persuaded by these arguments and rendered the more eager and ready, agreed entirely. It was therefore decided that a very large one should be built. A site was chosen in a certain garden of his own estate, about half a mile from the city, in the direction of the southwest [Notolybicum] (if I remember rightly), near a village called Göggingen [Gegginga]. Various craftsmen were hired — the more skilled in that city: clockmakers, goldsmiths, blacksmiths, and carpenters — and not a few of them, who undertook the work willingly and with one accord, partly to oblige the consul, partly drawn by the promptness of the pay. All the material was at hand ready: whether beams of the best and most solid wood, kept under cover and thoroughly seasoned by the great age of many years, or brass [orichalcum] plates and iron fittings to look to. Without delay, within the space of a single month, we built a quadrant of such bulk that it could scarcely be carried by twenty strong men from the place where it was being made to the nearby hill where it was to be set up — onto the pivot on which it was to be turned, already firmly fixed there beforehand. The form of the quadrant was nearly of this kind, such as the following picture represents. [Ipsum]

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Diagram. A full-page woodcut showing Tycho's great Augsburg quadrant in situ, mounted on a heavy timber stand set in an open garden landscape (grass, plants, and shrubs around the base). The instrument is the large quarter-circle (90°) quadrant: an open lattice-work triangular frame of crossed wooden bars (an

open grid of squares for lightness and rigidity), with the graduated arc running along its curved (lower) edge. The two straight sides meet at the apex (the center of the quadrant), where the sighting apparatus is mounted; the graduated limb sweeps below.

Readable labels and their positions:

- A (apex of the frame, at the top, the quadrant's center): center / pivot of sights
- G (upper left, at the apex region, end of one frame edge): corner of the frame
- E (upper right, at the apex region, near a small ring/eyelet): corner of the frame
- C (left-hand end of the graduated arc): the 0° / start end of the limb
- D (right-hand end of the graduated arc): the far end of the limb
- B (just below and right of D, at the outer edge of the arc): outer corner of the limb
- H (on the central support pillar, just below the arc): collar / joint of the supporting column
- I (to the right of the pillar, a screw/worm-screw projecting): adjusting screw [Margin device]
- O (left of the pillar, a screw/worm mechanism): screw mechanism
- N (right side, on the timber base block): corner of the base
- F (far right corner of the base block): corner of the base
- Q (left, on the base block): corner of the base
- S (lower left of the base block, on the top edge): corner of the base
- T (on the front face of the heavy timber base box): the base structure
- Y (lower left, at the foot of the base on the ground): foot of the base
- T [?] (lower right, at the foot of the base on the ground): foot of the base

Graduated-arc numerals legible along the limb (degrees, marked in tens): 10, 20, 30, 40, 50, 60, 70, 80, 90 — running from the C end up to the D/B end (full 90° quadrant).

[The graduated arc and several of the small peripheral letters on this woodcut are faint; positions of the base-block letters (Q, S, T, Y, X) are read from their placement on the timber stand.]

The quadrant itself, with its entire framework and crossbeams, is sketched by the figure ACB: its center is at A, its circumference at CB. The two sides that enclose

the right angle at the center, BA and CA, were made of oak, finely worked in the manner of great beams. They measured at least 14 cubits in length, with the arc CB corresponding to this dimension. They were skillfully assembled from a special solid timber and overlaid with brass on the surface that was exposed for the graduation. The transverse braces, too, which can be seen, were made of beams of suitable size, neatly fitted together and smoothed, so as to combine the plane and the sides of the instrument.

Sights [Pinnacidia] were fitted on the upper surface of the side AB, indicated by the letters E and D. The forward one of these, at D, had a hole in its middle, through which a star could be sighted near the upper edge [Diametrum] toward E, where for this purpose half of it was cut away. These were used for sighting. Whenever, however, the Sun had to be observed, another sight was used there, also pierced, so that it would admit the Sun's light into the interior of the forward plane, transmitted through a certain hollow channel that confined the rays. Near the center at A, in addition, a brass thread [filum Orichalcicum] was attached, carrying a plumb-weight of some several pounds lower down beside the hole H, serving in place of a perpendicular, so that by means of this thread the observed altitude could be marked off in the small fractions of the degrees.

Now this quadrant rested against a wooden column of oak, very thick and sturdy, and was fixed to it at the back near G by means of a round iron pin, supported at the same time by two struts [capreolis] fitted a little above the hole H. These too served the purpose of raising the quadrant itself when it was to be lifted

raised, or of holding it more tightly to the column when it was lowered, so that it could be steadied in whatever position one wished. The column itself, in its lower part, turned within a certain underground structure shaped to fit it, which is represented by the letters S, P, Y, X, firmly set in place. This rotation was accomplished by means of the handles O, N, and Q, L, and together with it the column carried the quadrant around to every quarter of the sky; and this it did quite freely and with the least trouble. For the lowest part of the column was pointed and rounded, resting in a conical socket beside K, and shod with steel both at the matrix and at the point, so that they would not easily wear away. All of this is grasped more readily from the figure itself than from a long verbal account. It must be understood that the whole of what is seen a little below the handles was concealed and entirely hidden beneath the ground, secured on every side with stones, so that the machine might rest upon a safe and fixed foundation. Such, then, was the construction of that enormous quadrant.

Its remaining use was not unlike that of smaller instruments, except that, on account of its size, it required certain portable ladders propped on a frame, by which one climbed up for the sake of sighting through the forward sight — especially when steeper altitudes had to be measured. Accordingly, by raising or lowering the instrument until some star was sighted exactly along the upper edge through the hole of the lower sight, the plumb-line marked on the circumference of the quadrant the degree and minute, and whatever fractional part of these, corresponding to the altitude sought.

This machine stood in the open air, since it was so large that it could not conveniently be housed under any roof without the view and the opportunity for observation being at the same time hindered, or made more diffi-

cult. Nevertheless, it was protected from the harm of the weather and of rains by certain coverings fitted on, which could be removed during observation. It happened nonetheless that, after it had stood there unharmed and unbroken for a full five years, at last, when a great storm came on — its flat side perhaps directly exposed to the violence of the wind from the opposite quarter — it collapsed: whether by some malice, or because its destiny now so decreed.

Mention of this instrument is made by that most celebrated philosopher and orator of our age, Petrus Ramus [Petrus Ramus], in a certain disputation against Schecchius [Simone Simoni / Jacob Schegk?], and also in his *Life* he commemorates it somewhere. For he had visited me, together with Hieronymus Wolfius [Hieronymus Wolf], a most learned man who had deserved excellently of letters both Greek and Latin, my own singular friend, while I was staying at Augsburg — and this unexpectedly, when he was passing through that city on his return to his homeland. Invited together by Johann Baptist Hainzel [Johann Baptist Hainzel], the Septemvir (of whom I spoke before), we went out to the country after dinner for the sake of viewing his machine, which greatly pleased him with much admiration, for he thought it incredible that so vast a mass could be brought into so neatly worked a form. He even urged me to publish something about its construction and use, and also about a certain sextant made in its likeness, which I described a little earlier (and which I was then using as well), although it was not so large. But I, keeping silent, was turning over in my mind that I would carry out in its own time — if Divine mercy should favor it — many other things far greater and more perfect than these.

Let this be enough concerning the occasion, structure, and use of this instrument. Now it is time for me to set out and report what sort of observations of the proposed New Star [New Star of 1572] the aforesaid Consul of Augsburg, Paulus

Hainzel [Paul Hainzel], obtained by means of these instruments and shared with me.

Maximum and minimum altitudes of this New Star, near Augusta Vindelicorum [Augsburg], carefully sought out by means of this quadrant of 14 cubits.

In the year 1572, on 14 November, at hour 8, minute 0, P.M., the New Star was on the meridian above the pole, and it then had its maximum altitude of 76 degrees, 1 minute, 34 seconds [part. 76. /.34].

On the 21st of the same month, at hour 7½ P.M., it was observed at the same maximum altitude of 76 degrees, 1 minute, 33¾ seconds [part. 76. /.33¾].

On the following day, at hour 7, minute 28, A.M., this New Star was found at its minimum altitude of 20 degrees, 1 minute, 9⅔ seconds [part. 20. /.9⅔].

On the 26th of the same month, at hour 7, minute 8, after midday, its maximum elevation was again found to be 76 degrees, 1 minute, 34 seconds [part. 76. /.34].

On the following day, at hour 7, minute 6, before midday, it was noted at its lowest declination [in citima declivitate] of 20 degrees, 1 minute, 9½ seconds [part. 20. /.9½].

In the year 1573, in the month of January, on the 3rd, at hour 4, minute 23, before midday, its minimum altitude was 20 degrees, 1 minute, 9¾ seconds [part. 20. /.9¾].

On the 4th of the same month, at hour 4¼ P.M., it attained its highest elevation of 76 degrees, 1 minute, 35 seconds [part. 76. /.35].

On the 3rd of March, at hour 0, minute 26, A.M., it was at its lowest declination of 20 degrees, 1 minute, 9½ seconds [part. 20. /.9½].

On the 12th of the same month, at hour 11, minute 54, P.M., its minimum altitude was seen to be 20 degrees, 1 minute, 9⅓ seconds [part. 20. /.9⅓].

Therefore, when all these observations — both at maximum and at minimum altitudes — are compared and weighed in the balance, this New Star is found to have had, when it was on the meridian above the pole, a maximum altitude of 76 degrees, 1 minute, 34½ seconds [part. 76. /.34½]. For this value, as it were, lies midway between the observations made in November and in January.

Its lowest elevation below the pole [Citima vero Elevatio infra Polum], by contrast, will be 20 degrees, 1 minute, 9½ seconds [part. 20. /.9½], which also holds the mean of all the rest, although the difference among them is in itself extremely small. So that —

Now, so that the elevation of the pole at the place where these observations were obtained may be known exactly, I will also record the maximum and minimum altitudes of certain circumpolar fixed stars — stars that do not set — taken with the same quadrant around the beginning of the year 1573. I find these among the observations sent to me by the aforementioned Consul Hainzel [Paul Hainzel]. From them I will investigate the elevation of the pole accurately, repeating the calculation several times, since this is altogether necessary for clearing up the matter I am pursuing.

Observations of certain circumpolar stars made at Gegging near Augsburg [Augustam Vindelicorum], for the purpose of determining the elevation of the pole there.

		G.	M.	S.
Altitude of the Pole Star [Stellæ Polaris Alt.] — Maxima	Maximum	51	22	15
Altitude of the Pole Star — Minima	Minimum	45	21	45
Difference of the two [Utriusque differentia]		6	0	30
Distance of the star from the pole [Distantia Stellæ à Polo]		3	0	15
Elevation of the pole sought [Altitudo Poli quæsitæ]		48	22	0

From this it is clear that the Pole Star at that time was three degrees and a quarter of a minute distant from the pole. We have since found that it gradually drew a little closer to the pole, so that in the following years, around their beginning, its distance from the pole stood as I will now set out — taking the change in steps of four years at a time.

The distance of Cynosura [the Pole Star] from the pole, observed with our own instruments.

	P.	I.	II.
Year [Anno] 1577	2	58	50
Year 1581	2	57	30
Year 1585	2	56	10

	P.	I.	II.
Year 1589	2	54	50

So, with my own instruments, ever since I moved to this island [Hven], I have observed year by year that the Pole Star's declination is increasing and that it is approaching nearer to the pole — so much so that in each year it came closer to the pole by very nearly a third of a minute, as I have also indicated above.

Now I will examine the observations of the other circumpolar stars as well, to see what elevation of the pole they yield, testing all of them — as many as Hainzel noted down as suitable for this purpose.

		G.	M.
Altitude of the preceding star in the flank of the Lesser Bear [Præcedens in Latere Ursæ minoris Alt.] — Maximum	Maxima	62	27¼
The same — Minimum	Minima	34	17
Difference of the two		28	10¼
Distance of the star from the pole		14	5⅛
Elevation of the pole sought		48	22

		G.	M.
Altitude of the star in the right hip of Cepheus [In dex. hu. Cep. Al.] — Maximum	Maxima	77	31⅔
The same — Minimum	Minima	19	11⅔
Difference of the two		58	20
Distance of the star from the pole		29	10
Elevation of the pole sought		48	21⅔

		P.	M.
Altitude of [the star] in the right flank of Cepheus, beneath the girdle [In dextro Lat. Cephei sub Cing. Altit.] — Maximum	Maxima	69	38½
The same — Minimum	Minima	27	5
Difference of the two		42	33½

		P.	M.
Distance of the star from the pole		21	16¾
Elevation of the pole sought		48	21¾

		P.	M.
Altitude at the springing of the tail of the Greater Bear [In eductione Caudæ Ursæ maioris Altit.] — Maximum	Maxima	78	55½
The same — Minimum	Minima	17	48½
Difference of the two		61	7
Distance of the star from the pole		30	33½
Elevation of the pole sought		48	22

		P.	M.
Altitude of the middle star in the tail of the Greater Bear [Mediæ in Caud. Ursæ maioris Altitud.] — Maximum	Maxima	81	9
The same — Minimum	Minima	15	36
Difference of the two		65	33
Distance of the star from the pole		32	46
Elevation of the pole sought		48	22½

		P.	M.
Altitude of [the star] in the shoulder of the Greater Bear [Quæ in Humero Ursæ maioris Altitud.] — Maximum	Maxima	74	18
The same — Minimum	Minima	22	26
Difference of the two		51	52
Distance of the star from the pole		25	56
Elevation of the pole sought		48	22

		P.	M.
Altitude of the left thigh of the Greater Bear [Sinist.	Maxima	82	16½

		P.	M.
Crus Ursæ Alt.] — Maximum			
The same — Minimum	Minima	14	28½
Difference of the two		67	48
Distance of the star from the pole		33	54
Elevation of the pole [Elevatio Poli]		48	22½

		P.	M.
Altitude of [the star] at the flanks of the Greater Bear [Quæ ad Ilia Ursæ maioris] — Maximum	Maxima	79	41
The same — Minimum	Minima	17	2½
Difference of the two		62	38½
Distance of the star from the pole		31	19¼
Elevation of the pole sought		48	21¾

		P.	M.
Altitude of the knee of Cassiopeia [Genu Cassiopeæ Alt.] — Maximum	Maxima	80	22½
The same — Minimum	Minima	16	22½
Difference of the two		64	0
Distance of the star from the pole		32	0
Elevation of the pole sought		48	22½

From all these results compared with one another, it follows that the elevation of the pole at Gegging near Augsburg, where the observations were made, is 48° 22' — quite precisely. For although the observation made through the middle star of the tail of the Greater Bear, together with the left leg and the knee of Cassiopeia, comes out half a minute larger, this happens through the refraction of those stars, which at their lower altitude were raised somewhat higher (as is shown elsewhere from optical principles). In the remaining cases the discrepancy is imperceptible.

I will also add the meridian altitudes of several fixed stars near the zodiac, taken with the same quadrant, together with the declinations derived from them. By comparing these with the declinations appropriate to that time from our own

observations, it can be established that this great quadrant gave sufficiently accurate altitudes, differing imperceptibly from those instruments which I later had made on this island and from which I afterwards determined magnitudes in various ways.

The meridian altitudes of several notable stars around the zodiac, observed near Augsburg [Augustam Vindelicorum], from which the declinations were found and are here compared with ours reduced to the beginning of the year 1573:

NAMES OF THE STARS	Merid. Altitude (P.)	Merid. Altitude (M.)	Declinatio	Declinatio	Declinatio n — Ours (P.)	Declinatio n — Ours (M.)
			n — Hainzel's (P.)	n — Hainzel's (M.)		
Prima Arietis [first star of Aries]	58	49	17	11 B.	17	10½ Bor.
Oculus Tauri [the Eye of Taurus, Aldebaran]	57	13	15	35	15	34½
Superius Caput II [the upper Head of Gemini]	74	21¾	32	43¾	32	43⅔
Inferius Caput II [the lower Head of Gemini]	70	37	28	59	28	59⅙
Cor Leonis [the Heart of Leo, Regulus]	55	39½	14	1½	14	1½

NAMES OF THE STARS	Merid. Altitude (P.)	Merid. Altitude (M.)	Declinatio	Declinatio	Declinatio n — Ours (P.)	Declinatio n — Ours (M.)
			n — Hainzel's (P.)	n — Hainzel's (M.)		
Spica Virginis [the Ear of Corn of Virgo, Spica]	32	46	8	52 M.	8	52¼ Mer.

Since the difference nowhere exceeds half a minute, it is quite clear that the altitudes taken with that great quadrant agree very closely with these instruments I later constructed, and are therefore subject to no doubt at all.

I have now reviewed a number of Hainzel's [Hainzeliana] observations made with that great quadrant near Augsburg, which will be of great use for examining the appearances of this New Star [Nova Stella]; for I do not believe it was observed anywhere else with so vast an instrument.

These records should be sufficient, both for the distances of this new star — already enumerated earlier by means of the sextant instrument — and for the altitudes that were measured with that quadrant, which I have also set out. There would be no point in reporting more, since this star remained perpetually in the same place, and these same recorded observations, even though repeated several times, fall out to exactly the same result. Nevertheless I will add, in passing, the right ascensions and declinations of the three principal stars of Cassiopeia, obtained by a special method in the year 1587.

In that year I found, between the transit of the Bright Star of the Chair [Lucida Cathedrae] across the meridian and that of Spica [Spicam ♍], an interval of 1 hour 15 minutes 55 seconds. With respect to Schedir, the interval was 0 hours 45 minutes 55 seconds. As for Flexura [the Bend], the interval was 0 hours 31 minutes 5 seconds.

From this, applying the right ascension of Spica Virginis for that time — which was 195 degrees 53 minutes — I gathered the right ascension of the Bright Star of the Chair to be 356 degrees 55 minutes. Its declination, observed at the same time, was 56 degrees 53 minutes.

In this way the right ascension of Schedir comes out to 4 degrees 24 minutes, its declination at that time being 54 degrees 16½ minutes.

Flexura, in turn, takes a right ascension of 8 degrees 8 minutes, and a declination of 58 degrees 28½ minutes.

These same values I confirmed by means of the equatorial armillae [Armillas Aequatorias], and found the ascensional differences to correspond — which I will now summarize.

The
ascensional
differences of
certain stars
of Cassiopeia

	From the Bright Star Υ (P.)	From the Bright Star Υ (M.)	From the Heart ϱ (P.)	From the Heart ϱ (M.)
Names of the stars	P.	M.	P.	M.
Lucid. Cathed. [Bright Star of the Chair]	29	6	30	21
Schedir	21	37	37	51
Flexura [the Bend]	17	53	41	34

If these ascensional differences are examined against the right ascension of the Bright Star of Aries [Lucida Υ] — which was then 26 degrees 11½ minutes — and against that of the Heart of Leo [Cordis Leonis], 146 degrees 33½ minutes, conversely, they will yield the very same values we earlier obtained from Spica over the elapsed interval. And if all these are brought forward to the completed year 1572, they will certainly agree with the right ascensions and declinations derived from the longitude and latitude, which I will present in the following chapter. How those longitudes and latitudes came to be known is clear from what I set out in the second chapter concerning the verification of the fixed stars, where I dealt most particularly with the constellation of Cassiopeia. Moreover, I have chosen to record the right ascensions of these three principal stars, obtained in another way from the heavens, together with their declinations, so that the very close agreement may testify that the positions of these three stars — whose

use was also of the first importance — are duly arranged according to the celestial standard. And just as in the remaining stars of Cassiopeia, so too in the proper designation of their places, the matter itself, which we are about to take up, will plainly prove that no fault lies hidden (since everything true is everywhere consistent with itself).

CAPVT QVINTVM.

CHAPTER FIVE.

On the precise place of this star — both in longitude and latitude with respect to the ecliptic, and in declination and right ascension with respect to the equator — investigated and demonstrated geometrically.

From what we brought forward in the third chapter, by way of a general consideration of this star's appearances, its position among the stars of Cassiopeia did indeed become clear, but only in a rather broad way. Now, however, by examining the whole matter more deeply and scrupulously, drawing on the distances from neighboring stars of the same constellation reviewed in the preceding chapter, we intend to inquire precisely into its true place, the one it actually held in the heavens.

The place of any star may be taken to be fully established only when its longitude from the vernal intersection [vernal equinox], with respect to the ecliptic, is known — that is, by drawing through the star, from the poles of the ecliptic, an arc of a great circle which, passing as far as the ecliptic, marks off the longitude itself — and when its latitude is likewise known according to the amount intercepted between the star and the ecliptic. These two things, in the case of the star here proposed, we will undertake to investigate first; for the positions of all stars, both wandering [planets] and fixed, together with their motions, are considered with respect to the poles of the ecliptic. Afterwards we will refer these same matters to the equator and its poles; and, so as not to indulge in long digressions, let us now approach the business itself.

But since the places of the stars of Cassiopeia must first be exactly known, so that through them we may arrive at knowledge of the unknown — namely, of the New Star — these are required as they stood at the end of the year 1572; for as much as...

when this star first appeared, let us now recall those positions which, in Chapter Two, we established from reliable observations for the stars surrounding this

constellation. I will select only the nine more important ones, passing over the rest, since they are not needed here. I will also add their declinations and right ascensions, so that everything—both with respect to the ecliptic and with respect to the equator—is readily at hand.

Beyond this, I will append both the Alphonsine and the Copernican positions in each of the two reference frames, so that the discrepancy between these and the heavens themselves may be evident, and so that, whenever one wishes to use them, they are ready to hand.

The arrangement of the nine selected stars of Cassiopeia, whose use is required here, as completed for the year 1572, directed both to the ecliptic and to the equator according to our observations.

N u m b e r	Names of the Stars	Long	Long	Latit	Latitu	R.	R.	Declin	Declina
		itude P.	itude M.	ude P.	de B.M.	Ascens ion P.	Ascens ion M.	ation P.	tion B.M.
1	Caput	29	11 γ	44	40½	3	26¼	51	32½
2	Schedir	1	53½ γ	46	35½	4	12⅔	54	11½
3	Cingulu m	4	14 γ	47	5	5	58⅓	55	31½
4	Flexura	8	3½ γ	48	46	7	56⅓	58	24
5	Genu	11	57 γ	46	22	14	36¾	57	58
6	Crus	18	49½ γ	47	29	21	9½	61	30⅓
7	Extr. pedis	26	15 γ	48	54	28	45⅔	65	23
1 1	In Erect. se.	6	42 γ	52	14	2	20⅔	60	34
1 2	Luc. Cath.	29	11½ γ	51	14½	356	43⅓	56	48½

According to Copernicus.

N u m b e r	Names of the Stars	Long itude P.	Long itude M.	Latit ude P.	Latitu de B.M.	R. Ascens ion P.	R. Ascens ion M.	Declin ation P.	Declina tion B.M.
1	Caput	28	59 Υ	45	20	2	38 $\frac{1}{6}$	52	0
2	Schedir	1	59 Υ	46	45	4	8	54	21 $\frac{1}{2}$
3	Cingulu m	4	9 Υ	47	50	5	6 $\frac{1}{3}$	56	5 $\frac{5}{6}$
4	Flexura	7	49 Υ	49	0	7	25 $\frac{3}{4}$	58	29 $\frac{1}{3}$
5	Genu	11	29 Υ	45	30	15	1 $\frac{2}{3}$	57	3 $\frac{5}{6}$
6	Crus	18	9 Υ	47	45	20	2 $\frac{2}{3}$	61	28 $\frac{1}{3}$
7	Extr. pedis	25	49 Υ	48	20	28	53	64	40 $\frac{5}{6}$
1 1	In Erect. se.	6	9 Υ	52	40	1	14 $\frac{1}{3}$	60	40 $\frac{5}{6}$
1 2	Luc. Cath.	28	59 Υ	51	40	356	2	57	3

According to the Alphonsine Tables.

N u m b e r	Names of the Stars	Long itude P.	Long itude M.	Lati tude P.	Latit ude M.	R. Ascens ion P.	R. Ascens ion M.	Declin ation P.	Declination B.M.
1	Caput	28	7 Υ	45	20	1	50	51	39 $\frac{1}{2}$
2	Schedir	1	7 Υ	46	45	3	18 $\frac{1}{2}$	54	0 $\frac{5}{6}$
3	Cingulu m	3	17 Υ	47	50	4	16	55	45 ¹ [source anomaly: bare superscript "1" where every other cell in this

N u m b e r	Names of the Stars	Long itude P.	Long itude M.	Lati tude P.	Latit ude M.	R. Ascens ion P.	R. Ascens ion M.	Declin ation P.	Declination B.M.
									column has a vulgar fraction — likely a damaged/in complete fraction glyph; transcribed as printed]
4	Flexura	6	57 ⅈ	49	0	6	34	58	8¾
5	Genu	10	37 ⅈ	45	30	14	6⅓	56	43⅝
6	Crus	17	17 ⅈ	47	45	19	2½	61	8⅝
7	Extr. pedis	24	57 ⅈ	48	20	27	44	64	26 ¹ [source anomaly: bare superscript "1" where every other cell in this column has a vulgar fraction — likely a damaged/in complete fraction glyph; transcribed as printed]
1 1	In Erect. se.	5	17 ⅈ	52	40	0	26	60	19½

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b e r	Names of the Stars	Long itude P.	Long itude M.	Lati tude P.	Latit ude M.	R. Ascens ion P.	R. Ascens ion M.	Declin ation P.	Declination B.M.
1	Luc.	28	7 ʹ	51	40	355	3½	56	36½
2	Cath.								

With these matters thus established as a foundation, let us first try the very thing we set out to do—by three separate routes—using the three most conspicuous stars of Cassiopeia, namely those which, being near this New Star, form a rhomboidal figure together with it. These are: Schedir, the star in the Breast, second in number, from which the New Star was distant $7^{\circ} 50\frac{1}{2}'$; the star in the Bend [Flexura], next to the hip, fourth in number, from which it was distant $5^{\circ} 2'$; and, in addition, Lucida Cathedrae, twelfth in order, which it left at an interval of $5^{\circ} 19'$.

With these data brought to bear, in the diagram drawn here let E be taken as the pole of the ecliptic, of which F I is some arc. Let the position A represent the topmost star, that is, Lucida Cathedrae; B, the star in the Bend [Flexura]; and D, Schedir. Let the New Star be at C. From the pole E, through these four points, quadrants of great circles are to be drawn until they meet the ecliptic at the points F, G, H, I. It is clear that these arcs indicate the longitudes of the stars, while their latitudes are measured by the arcs intercepted from here all the way to the stars themselves.

Since, as we said, the place of the New Star can be derived in three ways from this very figure, we will begin first of all from Lucida Cathedrae and Flexura, marked at A and B.

Diagram. A geometric construction for determining the place of the New Star from the Cassiopeia reference stars. At the top is the ecliptic pole E, from which long arcs (quadrants of great circles) fan downward toward the ecliptic line at the bottom, meeting it at the labeled points F, G, H, I (left to right along the base). In the middle of the figure is a small rhomboidal/lens-shaped cluster of four points joined by intersecting arcs: A (upper left), C (upper right, the New Star), B (right), and D (lower center). The arcs from pole E pass through these points and continue to the ecliptic.

- E (apex, top): the pole of the ecliptic [Polus Eclipticae]

- A (center-left of the small figure): the topmost star, Lucida Cathedrae [supremam vel Lucidam Cathedrae]
- C (upper right of the small figure): the New Star [Nova Stella]
- B (right of the small figure): the star in the Bend, Flexura
- D (lower center of the small figure): Schedir
- F (base, far left): point where the arc through A meets the ecliptic
- G (base, left-center): point where the arc meets the ecliptic
- H (base, right-center): point where the arc meets the ecliptic
- I (base, far right): point where the arc through B meets the ecliptic

To investigate the place of the New Star by means of Lucida Cathedrae and the star in the Bend [Flexura] of Cassiopeia.

I.

Since in triangle A B E two sides are given together with the angle they enclose—A E being the complement of the latitude of the star in the Chair [Cathedra], $38^{\circ} 45\frac{1}{2}'$, and side B E the complement of the latitude of the star next to the hip, in the Bend [Flexura], $41^{\circ} 14'$; while the angle A E B contained by these is measured by the difference of longitude of those same stars, $8^{\circ} 52'$ —the remaining side B A cannot, therefore, fail to be found: $6^{\circ} 12\frac{1}{2}'$. This represents the mutual separation of the stars assumed here, and it agrees well enough with what was instrumentally observed in the heavens; it is in excess by only about half a minute [scruple], which is here imperceptible.

And since now all three sides of this same triangle are settled, the angle E A B will become known through the Operation of Spherical Triangles [per Operationem Triangulorum Sphaericorum]: $110^{\circ} 1' 47''$.

Next, in triangle A C B: since all three sides are known—A C being $5^{\circ} 19'$, by the distance of the New Star from the topmost star in the Chair [Cathedra]; B C, between this star and Flexura, $5^{\circ} 2'$; and B A itself, the separation of the fixed stars, $6^{\circ} 12\frac{1}{2}'$ —the angle B A C will also be obtained, $51^{\circ} 9' 2''$. When this is subtracted from the angle E A B previously found, as a part is taken from its whole, it leaves the angle E A C, known in triangle A E C: $58^{\circ} 52' 45''$.

Now, therefore, passing to the said triangle A E C: since two of its sides are known together with the angle between them—A E being $38^{\circ} 45\frac{1}{2}'$, the complement of the latitude of Lucida Cathedrae, and A C being $5^{\circ} 19'$, namely the distance of the New Star from this same star, while the angle C A E has just been indicated—the

third side C E therefore comes out as $36^{\circ} 15' 9''$, which is the complement of the latitude...

this gives the latitude of the New Star. And from what has now been laid open, the angle AEC in the same triangle will not escape us either: it comes out to $7^{\circ} 42' 34''$. This angle measures the arc of the ecliptic FH lying between the longitude of the bright star in the Throne of Cassiopeia [Schedir] and that of the New Star. Therefore, since the more recent star lies farther on in the order of the signs than the Throne of Cassiopeia, this difference must be added, so that the sought longitude of the New Star works out to $6^{\circ} 54' 48''$. Its latitude, taken from the complement indicated earlier, comes to $53^{\circ} 44' 51''$ — and these are the two things we set out to investigate by the foregoing procedure together.

Now, taking up the bright star in the Throne together with the one in the Breast, we shall examine the same matter by a like method of reasoning.

From the Bright Star of the Throne and the Star in the Breast of Cassiopeia — called Schedir — to find out its place.

II.

The data to be assumed here are as follows. The distance of the New Star from the bright star of the Throne is, as before, $5^{\circ} 19'$; and from Schedir, $7^{\circ} 50\frac{1}{2}'$. Let the place of Schedir be D, with everything else standing as before. So, first working out the triangle AED, from its two given sides — DE, by the complement of the latitude of Schedir, $43^{\circ} 24\frac{2}{3}'$, and AE, by the complement of the latitude of the bright star of the Throne, $38^{\circ} 45\frac{1}{2}'$ — together with the one known angle enclosed between them, taken by the difference of longitude of those same stars, $2^{\circ} 42'$, the third side DA is found to be $4^{\circ} 59'$. This indicates the separation of the two stars from each other, and it agrees extremely well with what was observed.

Therefore, from the three now-given sides of that same triangle, the angle ADE is revealed to be $19^{\circ} 59' 50''$.

Furthermore, in triangle ADC — where the three sides are likewise given: DC, the distance between the bright star in the Breast and the New Star, $7^{\circ} 50\frac{1}{2}'$; AC, the distance between the bright star of the Throne and the same star, $5^{\circ} 19'$; and AD, from Schedir to the brighter star of the Throne, $4^{\circ} 59'$ — the angle ADC therefore comes out to $42^{\circ} 6\frac{1}{2}'$. If from this the previously found angle ADE is subtracted, the angle CDE remains, in this very triangle CDE, which we shall now take up.

In the triangle just named, CDE: since the side DE is known by the complement of the latitude of the star Schedir, and DC by the distance of the New Star from it (as

indicated before), and the angle CDE enclosed by these has likewise been made plain by the reasoning just given to be $22^{\circ} 61' 40''$, the third side CE also comes out into the open as $36^{\circ} 14' 55''$ — which is the complement of the latitude of the New Star. And further, from the three known sides, the angle DEC — the difference of longitude from Schedir — will not be unknown: $5^{\circ} 0' 9''$. So, when this is added to the longitude already fixed for the star in the Breast of Cassiopeia, the place of this new beacon comes out as removed from the vernal equinox by $6^{\circ} 53' 39''$. And the side CE gives its latitude-complement as $53^{\circ} 45' 5''$ — which were the things to be sought.

The same — to investigate it by the distances from Schedir and from the star in the Bend of Cassiopeia.

III.

Since the New Star was separated from the one that lies in the Bend by the Side of Cassiopeia by $5^{\circ} 2'$, and from Schedir (as stated) by $7^{\circ} 50\frac{1}{2}'$ — let B, in this same configuration, be the Bend of Cassiopeia, with the rest understood in the same way as before.

In the triangle DEB, from the known side BE — by the complement of the latitude of the Bend, $41^{\circ} 14'$ — and DE, by the complement of the latitude of Schedir, $43^{\circ} 24\frac{2}{3}'$, together with the angle DEB known through the difference of longitude of the two stars, $6^{\circ} 10'$, the third side DB comes out as $4^{\circ} 40\frac{1}{2}'$ — exceeding the observed distance by at most half a scruple [a half-minute]. And one angle of the same triangle, EBD, is found to be $115^{\circ} 2' 10''$.

Next, in triangle BCD — since the three sides are likewise had: BC, by the distance of the New Star from the Bend, $5^{\circ} 2'$; DC, the distance of the same from Schedir, $7^{\circ} 50\frac{1}{2}'$; and DB, the distance of the fixed stars from each other, $4^{\circ} 40\frac{1}{2}'$, as all this has already been made plain before — the angle CBD will be computed as $107^{\circ} 35' 0''$. When this is subtracted from the angle EBD found earlier, the remainder gives the angle CBE in the other triangle, which we shall now treat.

At length, therefore, in triangle BCE: from the angle CBE known by the reasoning just stated, $7^{\circ} 27' 10''$, and from the sides enclosing it on either side — BE and BC, already made plain — the third side CE cannot stay hidden: $36^{\circ} 15' 10''$. And from the three sides now in view, the angle CEB presents itself as $1^{\circ} 9' 50''$, indicating the difference of longitude of the New Star from the Bend. And since the star next to the Side of Cassiopeia lies farther on in the consequents than this New Star, by subtracting this differential angle from the place of the Bend on the ecliptic we

obtain the longitude of the New Star: $6^{\circ} 53' 40''$. Its latitude too, established by the arc CB which yields the complement of it, will stand at $53^{\circ} 44' 50''$ — the two quantities that were to be found out.

Up to this point I have tracked down the place of the New Star by a threefold investigation drawn from three native stars of Cassiopeia, in respect of longitude and latitude, presenting it just as a single prior configuration allowed me to display by representing it in this way. Now, by three slightly different schematic figures, derived from yet other and other stars of Cassiopeia, we shall scrutinize the same matter by a closely similar line of inductive reasoning, so that — with all the new assumptions brought to bear right through —

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— the place of the star with which we are dealing may come out investigated in manifold ways, and so emerge more certain and more evident. For variety in itself gives pleasure, and it draws the consistency of the truth that much more clearly into the open.

To test it against the star in the Head of Cassiopeia, and against the one placed at its Knee, in the modern reckoning.

III.

In the adjoined figure, let A be the Head of Cassiopeia, from which the New Star was distant $10^{\circ} 22'$; C the Knee of the same, at a remove of $8^{\circ} 3\frac{1}{2}'$; and the rest is understood from what has gone before.

Diagram. A tall, narrow figure occupying the outer (right-hand) margin of the page. The apex is at the top, marked **E** (the pole of the ecliptic), from which several straight lines descend to a horizontal base line running along the foot of the figure. The base line carries three points, left to right: **F**, **G**, **H**. An arc swings across the interior of the figure, on which three further points are marked: **A** (lower left, on the arc), **C** (upper, on the arc), and **B** (right, where the arc meets the right-hand descending line). The configuration corresponds to the spherical-triangle construction described in the text (triangles ABE, ABC, with the ecliptic base F–G–H and the pole E).

- E (apex, top): pole of the ecliptic
- A (on the arc, lower left): Head of Cassiopeia
- C (on the arc, upper middle): Knee of Cassiopeia

- B (on the arc, right): the New Star [reference point of the triangle]
- F (base, left): foot point on the ecliptic
- G (base, middle): foot point on the ecliptic
- H (base, right): foot point on the ecliptic

First, then, in triangle ABE: since the latitude AE is given, $45^{\circ} 19\frac{1}{2}'$, and BE, $43^{\circ} 38'$ — both arising from the complements of the assumed fixed stars — and the angle intercepted, BEA, is taken from the difference of longitude as $12^{\circ} 46'$, the side BA, which indicates the distance of the stars, is worked out as $9^{\circ} 5\frac{1}{2}'$, differing imperceptibly from what was observed. And so, from the three known sides, the angle BAE will be $74^{\circ} 46' 10''$.

Afterwards, in triangle ABC: from the side AC, $10^{\circ} 22'$, and BC, $8^{\circ} 3\frac{1}{2}'$, and likewise AB, $9^{\circ} 5\frac{1}{2}'$, as has already been made plain, there comes out — from these three known sides, that is — the angle CBA of 48° ...

$48^{\circ} 35' 25''$. When this is subtracted from angle BAE, found in the earlier triangle, it leaves CAE known, at $26^{\circ} 10' 45''$, which we shall use in the next triangle.

And so, finally, in triangle CEA — from the given side AE and AC, as appeared from what precedes, and with the intercepted angle CAE (just determined, as we have said) — the third side CE, representing the complement of the latitude, will not be wanting: $36^{\circ} 15' 10''$. And once these three sides are established in this same triangle, angle AEC will be revealed as $7^{\circ} 42' 56''$, measuring the difference in longitude of the New Star from the star at the head of Cassiopeia. The result, therefore — given the arrangement considered along the path of the ecliptic — is that the longitude of this new beacon falls at $6^{\circ} 53' 56''$ of [the sign], with its latitude coinciding with the previously determined complement CE, at $53^{\circ} 45'$, the sixth seconds [scrupuli] alone falling short [of the prior value]. Which is what we had to find.

This same result is now to be confirmed once more, from the star next to the girdle of Cassiopeia below the breasts — the third in number — and from the one near the leg, which is sixth in order.

V.

The data we shall use here are as follows. The New Star was distant from the one in the girdle by $6^{\circ} 53'$, and from the one in the leg by $9^{\circ} 48'$. Accordingly, in the next following figure — understanding that A indicates the girdle of Cassiopeia and B the star in the leg, while the rest stand as before — these results will follow.

In triangle BEA, side AE is $42^{\circ} 55'$ and BE is $42^{\circ} 31'$, both known through the complements of the latitudes of the stars; and the intercepted angle AEB, $14^{\circ} 35\frac{1}{2}'$, which the difference in longitude supplies. Therefore the third side BA comes out as $9^{\circ} 53\frac{1}{2}'$.

in sufficient agreement with the observed distance of the stars; and furthermore angle EBA comes out as $86^{\circ} 55' 41''$.

In the other triangle ABC, side BC is $9^{\circ} 48'$, AC is $6^{\circ} 53'$, and AB is $9^{\circ} 53\frac{1}{2}'$, as is clear from what was said before; these will yield angle BAC at $41^{\circ} 6' 7''$.

Finally, in triangle BCE — from side BE and BC, together with the angle interposed between them, EBC (obtained by subtracting the just-determined BAC from EBA, known in the first triangle), at $45^{\circ} 49' 34''$ — the third side CE will not allow itself to remain hidden: $36^{\circ} 14' 53''$, supplying the complement of the star's latitude. And from these three given sides, the angle at E will likewise be established at $11^{\circ} 55' 14''$, which — being subtracted as the difference of longitude from the star in the leg — furnishes [the result]. It follows, then, from these, that the longitude of this New Star falls at $6^{\circ} 54' 16''$, together with the northern latitude, from the previously found complement CE, of $53^{\circ} 45' 7''$. And these were the two things we set out to demonstrate and resolve into numbers by this fifth line of reasoning.

Diagram. A spherical-triangle schematic for the fifth determination of the New Star's place. From an apex E at the top, two curved meridian-like arcs sweep down to the base, which is marked by the points D, E, F at the foot (D left, E center, F right). Within the figure, points A, C, and B form the working triangle: A at left, C above and between, B at right, with arcs connecting A–C–B. The construction shows triangles ABC, BCE, and BEA used in the text.

- E (apex, top): vertex E — the ecliptic pole
- C (upper middle): the New Star
- A (left of center): the girdle star of Cassiopeia
- B (right): the leg star of Cassiopeia
- D (base, left): foot point D
- E (base, center): foot point E
- F (base, right): foot point F To confirm yet again the same result as before, from the eleventh star, which is in the middle of the seat [Sella], and from the seventh, placed next to the extremity of the foot.

VI.

That eleventh star, indicated in the attached figure by A, was distant from the New Star by $1^{\circ} 31'$. The other one, seventh in number, placed at the bottom of the foot, to be understood at B, was removed by $12^{\circ} 58\frac{1}{2}'$. Therefore, with the rest holding constant as before, the derivation of the triangles will proceed thus.

Triangle ABE, having its sides known — AE at $37^{\circ} 46'$, BE at $41^{\circ} 6'$, through the distances of the stars from the ecliptic pole, together with the intercepted angle AEB, from the difference in longitude, $19^{\circ} 33'$ — will readily reveal the remaining side BA at $12^{\circ} 49'$, departing very slightly from the observation itself, and will at the same time disclose angle ABE at $67^{\circ} 32' 7''$.

Next, in triangle ABC — from sides AC and BC indicated, together with BA just found, as if from three known sides — the angle at B will not be concealed: $6^{\circ} 45' 45''$; and this, subtracted from angle ABE found in the prior triangle, will leave angle CBE known, at $60^{\circ} 46' 22''$.

Diagram. A spherical-triangle schematic for the sixth determination, parallel in construction to the figure on the facing page. From apex E at the top, two curved arcs descend to the base marked F, G, H at the foot (F left, G next to it, H right). The working triangle is formed by A (left), C (upper middle, the New Star), and B (right), with arcs joining A–C–B.

- E (apex, top): vertex E — the ecliptic pole
- C (upper middle): the New Star
- A (left of center): the eleventh star, in the middle of the seat of Cassiopeia
- B (right): the seventh star, at the bottom of the foot
- F (base, left): foot point F
- G (base, near F): foot point G
- H (base, right): foot point H

From these, in the third triangle BCE, there is found — from the two given sides and the angle intercepted between these three now conceded — side CE at $36^{\circ} 15' 20''$, which determines the complement of the star's latitude; and likewise angle CEB, not unknown from the three established sides, at $19^{\circ} 20' 57''$. This yields the difference in longitude of the New Star from the one at the extremity of the foot of Cassiopeia, and, combined, gives the sought longitude at $6^{\circ} 54' 3''$; while the latitude, emerging from the complement of arc CE, comes out at $53^{\circ} 44' 40''$ — which is what we set out to find by this sixth turn as well.

I have now verified the place of the New Star six times, from its distances to various stars of Cassiopeia. Indeed, I wish to test the same a seventh time, going further still, by yet another method — through the declinations and right ascensions of two stars intercepting the New Star, employing also the declination of this new heavenly body (found in the preceding chapter from its meridian altitudes), so as to confirm it, together with its distance from the fixed stars. The aim is that, once known on this side, by an inverse procedure the right ascension may first be established in the modern manner [Ascensio Recta Neoterica] used by us elsewhere, and then the longitude and latitude may be composed and compared with what was found before.

Now among the stars of Cassiopeia mentioned, none are found more suitable for this task than the brighter one in the chair [Cathedra], and the other next to the extremity of the foot; for between these two the New Star was in a manner interposed. We shall therefore use these, now looking toward the Pole of the World [Polus Mundi], from which this reasoning proceeds toward the Equator.

To determine the right ascension of this star from the Bright Star of the Throne [Schedar] together with the foot's extremity, and from this — by means of the declination — to conclude its longitude and latitude.

VII.

In the accompanying figure, let A be assumed as the Pole of the Equator, and E a portion of the same. The stars that I use here are: B, the Bright Star of the Throne [Schedar, the *Lucida Cathedrae*]; D, the extremity of Cassiopeia's foot; and C, that New Star — from each of which three quadrants of great circles descend, from the Pole down into its arc, as may be seen in the drawing itself.

Diagram. A tall, narrow spherical-triangle construction. The apex A (the Pole of the Equator) sits at top; three nearly vertical curved lines descend from A to a base line EFG at the bottom. Across the upper-middle of the figure a short transverse arc bears the labels B, C, D from left to right (B = the Bright Star of the Throne; C = the New Star; D = the extremity of Cassiopeia's foot), with C set slightly below the B–D arc. The three descending lines meet the base at E, F, and G.

- A (apex, top): Pole of the Equator
- B (mid-left, on transverse arc): the Bright Star of the Throne [Schedar]

- C (middle, just below the arc): the New Star
- D (mid-right, on transverse arc): extremity of Cassiopeia's foot
- E (base, left): foot of the line from B
- F (base, center): foot of the line from C
- G (base, right): foot of the line from D

Therefore, first, in triangle BAC: side BA is given, from the complement of the declination of the Bright Star of the Throne, as $33^{\circ} 11\frac{1}{2}'$; side AC, from the complement of the declination of the New Star — just as it was found by us, $28^{\circ} 13'$, by observation; and the third side, CB, from the distance of the stars from one another, $5^{\circ} 19'$. I say that, these three sides being known, the angle BAC will not remain hidden: it is about $3^{\circ} 42'$, which discloses the difference in right ascension of the New Star from the Bright Star of the Throne. And since the right ascension of the latter is $356^{\circ} 43\frac{1}{2}'$, by adding this ascensional difference, the right ascension of the New Star comes out as $0^{\circ} 25\frac{1}{2}'$.

But let us also test the same thing the other way around, in the other triangle, where side CA remains as before, while AD — the complement of the declination of the foot's extremity — is $24^{\circ} 37'$, and DC — the distance of the New Star from this same star — is $12^{\circ} 58\frac{1}{2}'$. Therefore here too, from the three given sides, the angle CAD will not be unknown: it is $28^{\circ} 19'$ very nearly. When this is subtracted from the right ascension of the little star at the foot's extremity — which was $28^{\circ} 45\frac{1}{2}'$ — there results the right ascension in this case of the New Star, $0^{\circ} 26\frac{1}{2}'$, which exceeds the former by a single minute. Taking, then, the mean between these, the truer and more precisely determined right ascension comes out as $0^{\circ} 26'$, established quite exactly.

Now from the declination and right ascension thus obtained, we shall extract the longitude and latitude according to the accompanying figure, in which A represents the Pole of the Equator and B the ecliptic; the semicircles drawn here are self-evident.

Diagram. A circle representing the sphere, with several great-circle arcs crossing its interior. A is at the top; B at the upper left; F at the upper right; the points I (far left) and K (far right) lie on the bounding circle near the horizontal diameter; H is at the lower left. In the interior the points C, D, G, and E mark intersections of the crossing arcs, with G near the center and E just below it. The arcs join these to form the spherical triangle ABC used in the working below.

- A (top): Pole of the Equator
- B (upper left): the ecliptic

- C (interior, upper-middle): the New Star
- D (interior, mid-right): [intersection of arcs]
- E (interior, just below center): [intersection]
- F (upper right): [pole of the ecliptic / arc endpoint]
- G (interior center): [intersection]
- H (lower left, on circle): [arc endpoint]
- I (left, on circle): [arc endpoint]
- K (right, on circle): [arc endpoint]

Let C be the New Star, through which quadrants are drawn to both poles, as is plain in the figure itself. In triangle ABC there will be: from B, the distance of the poles, according to our finding, $23^{\circ} 31\frac{1}{2}'$; CA, the complement of the declination of the New Star, $28^{\circ} 13'$; and the angle BAC, $90^{\circ} 26'$ — that is, with the right ascension added to the quadrant, so that it is reckoned from the winter tropic. From these two sides together with the contained angle, side BC comes out as $36^{\circ} 14\frac{2}{3}'$, which indicates the complement of the latitude of the New Star; and on this account, likewise from the three now known, the angle ABC will stand at $53^{\circ} 6'$ very nearly, which supplies the distance of the New Star from the tropic of Cancer. With this subtracted, then, from 90° — namely the remove of the summer solstice from the vernal equinox — there results the elongation of the New Star from the point of the vernal equinox, $36^{\circ} 54'$. Its longitude therefore falls at $6^{\circ} 54'$ of Taurus [♉], the latitude coming out, from the complement obtained earlier, as $53^{\circ} 45\frac{1}{8}'$. This is what we said was to be sought by this seventh method.

It is therefore evident that the longitude and latitude obtained in this seventh way — through ascensional differences and declinations — agree quite aptly with the preceding six.

Now, so that these seven longitudes and latitudes of the New Star, computed by different methods, may be set more closely before the eye one by one, and so that it may be seen how little they differ from one another, I shall now gather them all together summarily in a short table.

Longitudes and latitudes of the New Star, demonstrated seven times in different ways from the neighboring stars of Cassiopeia.

O rd	Names of the stars employed in the asterism of Cassiopeia	Long.			Lat.		
		P.	Long. '	Long. "	P.	Lat. '	Lat. "
1	Flexura & Lucida Cath.	6	54	4	53	44	51

Ordo	Names of the stars employed in the asterism of Cassiopeia	Long.			Lat.		
		P.	Long. '	Long. "	P.	Lat. '	Lat. "
	[the Bend & the Bright Star of the Throne]						
2	Lucida Cath. & Schedir [the Bright Star of the Throne & Schedar]	6	53	39	53	45	5
3	Flexura & Schedi [the Bend & Schedar]	6	53	40	53	44	50
4	Capite & Genu [the Head & the Knee]	6	53	56	53	44	59
5	Cingulo & Crure [the Girdle & the Leg]	6	54	16	53	45	7
6	Med. Cath. & Extr. pedis [the Middle of the Throne & the foot's extremity]	6	54	3	53	44	40
7	Luc. Cath. & Extr. pedis [the Bright Star of the Throne & the foot's extremity]	6	54	0	53	45	10

The header column "Ordo" carries the bracketed letter **A** in the margin alongside rows 4–7 (a brace grouping the entries). The two main column groups are both headed "NOVAE STELLAE" ["Of the New Star"], subdivided into "Longitudo" and "Latitudo," each in degrees (P.), minutes ('), and seconds ("). All longitudes are in Taurus [♉].

From this it is sufficiently apparent how accurately and finely the place of this star has been explored by the preceding reckonings, since the discrepancy — where it is nearly greatest — is only about half a minute, which is here truly of no moment.

Nevertheless, by reconciling these results with one another and refining them with what precision is possible — that is, by taking the mean of the greatest and the least of the little differences — the longitude of the New Star will come out as 6° 53' 57" of Taurus [♉], where, since scarcely three seconds are wanting to the completion of a whole minute, we shall have set down its longitude precisely

enough if we declare it to have been absolutely fixed at $6^{\circ} 54'$ of Taurus, the latitude being likewise $53^{\circ} 45'$ — since here too, away from the intermediate fineness, at least five seconds are altogether beyond reckoning. All of this, which I have hitherto striven to test in this manifold way, I have at last endeavored to render exactly explored.

To weigh the longitude of the New Star from its declination and latitude alone.

I should like, further, to test the longitude from the declination of the star itself together with its latitude — now so many times explored — just as we did in Chapter 2 with Spica of Virgo [♍], following the example of Copernicus [Copernicus], but with a readier method of computation, which here too I shall set out compendiously. Nor shall I need any other figure than the one used just before, which is therefore to be applied here.

The designations are to be understood as before: side BA is here too $23^{\circ} 31\frac{1}{2}'$, and CA is $28^{\circ} 13'$, from the complement of the declination of the star.

Diagram. The same spherical-sphere construction repeated for this final method. A is at the top; B at the upper left and F at the upper right; the circle's left and right limbs carry I (left) and K (right); H is at the lower left. Interior intersection points are C (upper-middle), D (mid-right), G (center), and E (just below center). The crossing great-circle arcs reproduce the triangle ABC used above.

- A (top): Pole of the Equator
- B (upper left): the ecliptic
- C (interior, upper-middle): the New Star
- D (interior, mid-right): [intersection]
- E (interior, just below center): [intersection]
- F (upper right): [arc endpoint]
- G (interior center): [intersection]
- H (lower left, on circle): [arc endpoint]
- I (left, on circle): [arc endpoint]
- K (right, on circle): [arc endpoint]

and the complement of the latitude gives $36^{\circ} 15'$. From these three known quantities, then, the angle ABC will be determined — the angle that expresses the difference in longitude from the tropic of Cancer [Tropico ♋] — coming to very nearly $53^{\circ} 5\frac{1}{2}'$. From this it follows that the star's longitude falls at $6^{\circ} 54\frac{1}{2}'$ Taurus [♉], exceeding the earlier reckoning by at most half a scruple [scrupulum] — a

discrepancy that, in a calculation of this kind, may readily be excused. For an alteration of even a few seconds in the declination or the latitude, although in itself imperceptible, increases the variation in longitude by more than double. Indeed, if we assume a declination smaller by at least a quarter of a minute, while keeping the same latitude as before, the resulting longitude comes to $6^{\circ} 54'$ Taurus [♉] — agreeing precisely enough with the value we collected earlier, so that there can be no doubt that this stands exactly right.

Since, however, we have now touched upon declination and right ascension once and again, it seems good to derive these too from the previously established longitude and latitude, and so to confirm them in turn. For at the outset we promised a thorough investigation of these quantities as well, with respect to the equator.

To construct the declination and right ascension of this star — found and duly examined by means of its longitude and latitude on a number of occasions.

Here too there will be no need of any diagram other than the one we have already used twice, and everything is to be conceived just as before. So, in triangle BAC, the side BA will be $23^{\circ} 31\frac{1}{2}'$, by the interval between the poles [intercapedinem Polorum]; the side BC will be $36^{\circ} 15'$, by the complement of the latitude.

Diagram. A spherical-triangle figure inscribed in a circle, repeating the construction used earlier in the chapter. Several great-circle arcs cross within the bounding circle, with their intersections lettered. Labels read, by position:

- A (top of circle): vertex A
- B (upper left): vertex B
- F (upper right): vertex F
- C (upper middle interior): intersection C
- D (middle-right interior): intersection D
- G (lower middle interior): intersection G
- E (bottom interior): intersection E
- I (left edge): point I
- K (right edge): point K
- H (lower left edge): point H

The angle ABC, for its part, is determined from the star's distance from the beginning of Cancer [♋], which is $53^{\circ} 6'$; from this the third side, CA, cannot escape being $28^{\circ} 13\frac{1}{4}'$. And now, from the three known sides, the angle BAC also comes out into the open as $9^{\circ} 26' 25''$. Therefore, once we discard the quadrant that runs from the winter solstice to the vernal equinox, the right ascension itself remains, to be counted from the vernal intersection, as $0^{\circ} 0' 26'' 25'''$ — the declination, coinciding with the complement stated above, being $61^{\circ} 46\frac{3}{4}'$. These two quantities, established precisely enough, I also chose to test and verify in the following way.

Now there is a very slight discrepancy between these and the values for right ascension and declination that we recorded earlier — so slight that in the declination only a quarter of a single minute is wanting, while in the right ascension two-fifths are in excess; which deserves no consideration at all. If, however, anyone wishes to be exceedingly scrupulous here, let him rather rely on the values drawn from the longitude and latitude, since these have been so often explored and ascertained, in preference to the others.

But to add this point as well: from the given right ascension of this New Star [New Star of 1572], without any further demonstration or computation, by means of the Table of Right Ascension drawn up by us in Chapter 1 [Tabulam Ascensionis Rectæ Cap. 1.], it is gathered that this unusual star crossed the meridian together with $0^{\circ} 29'$ of Aries [♈] when it stood on the meridian above the pole. And when it was placed below it on the same meridian, just as many degrees from the beginning of Libra [♎] were culminating. And so, as nearly as possible, its passage across the meridian occurred half a degree from the equinoctial points, in the direction following it; or, if one cares to examine the matter with full precision — as much as the simple semidiurnal motion of the Sun requires — by just that much was it distant from the equinoctial point.

This I unravel rather minutely for the following reason: I judge that something of hidden significance lies concealed here regarding the portents of this star — granting, that is, that anything in these matters has been allowed to earthborn men to foretell. Namely, why the star was not set exactly upon the equinoctial colure [Coluro Æquinoctiorum] itself, as many who scanned its appearances with a coarser inquiry supposed; nor yet somewhat before that colure, but rather a little after it, regarding the very middle of the first degree of Aries [primi gradus Æquinoctialis]. About these things I shall perhaps set out my own conjecture in its proper place. Here I only add this much: that in that region of the heavens where the star itself was placed, it stood scarcely a sixth part of one degree

distant from the said colure, measured along the arc of a great circle — the ascensional difference of the arcs being there compressed by that interval, on account of the breadth of the declination, and on account of its drawing near, at roughly the third part of a quadrant toward the pole, to the portion intercepted between that colure and the equator. And so it was so close to the equinoctial colure that it all but touched it with its rays, while yet standing forth with its whole body toward the region following.

So much, then, for the longitude and latitude of this star with respect to the ecliptic, and for its declination, right ascension, and position with respect to the equator — all of which, as we resolved at the outset to define exactly, have now been more than sufficiently reviewed and demonstrated.

Now, so that the sum of all that we have hitherto investigated so diligently concerning these matters may lie open to the eye in a brief display, I shall set it all down in one small table, gathered in so manifold a way without laborious computation.

The often-explored and confirmed place of the New Star, both with respect to the ecliptic and to the equator.

			P . M.
Respectu (With respect to)	Eclipticæ (the ecliptic)	Longitudo (Longitude)	6 54 ⅈ
		Latitudo (Latitude)	5 45 B. 3
	Æquatoris (the equator)	Asc. Recta (Right Ascension)	0 26⅔
		Declinatio (Declination)	6 46¾ 1 B.
Coeli mediatio (Culmination / meridian transit)			0 29 ⅈ

These values, established in this manner, I do not doubt to have been found so accurately that a deviation of half a minute or beyond is by no means to be admitted — so that the manifold method of investigation, everywhere converging upon a single goal, sufficiently attests it. It would certainly not have been possible

to attain such precision unless the distances of the stars had been duly observed, and their places verified against the exact standard of the heavens.

But that it may be evident how greatly it matters that the places of the fixed stars [fixed stars] be restored exactly before one may permissibly deduce from them the precise position of the planets or of some other phenomenon — and how necessary and useful was the labor we expended in rectifying the places of the fixed stars in Chapter 2 [Cap. 2] — let this at least appear in some measure from the following. It is my pleasure to investigate what positions of this New Star emerge from a number of prescribed distances together with the assumed Copernican [Copernicus] and Alphonsine [Alphonsine] places of the fixed stars — positions that turn out to agree less aptly — and to note them briefly in passing, so that, dissonant compared with consonant, they may make the certainty of the truth shine forth more fully.

A test of the New Star's position, arranged according to the places of the fixed stars by the Copernican reckoning.

Here let us make use of those three stars with which the nova forms a rhomboidal figure. Their positions for the given time — with the Copernican precession of the equinoxes duly added (which was then $27^{\circ}1'49''$ [part. 27.1.49]), measured from the first point of Aries [γ , "à prima γ "] up to the star's own remove — come out as follows, just as I noted at the very beginning.

NAMES OF THE STARS	Longitude (G.)	Longitude (M.)	Latitude (G.)	Latitude (M.)
Lucida Cathedrae	28	59 γ	51	40
Schedir	1	59 τ	46	45
Flexura	7	49 τ	49	0

[The zodiac-sign symbols in the longitude column: γ (Aries) for Lucida Cathedrae, τ (Taurus) for Schedir and Flexura.]

Here too, just as I did earlier from the places derived from my own stars, I am happy to investigate where this nova falls. So, taking up again the same figure I used before, everything proceeds by the following reasoning.

FIRST [PRIMO]

To find the place of the nova by the Copernican data, from Lucida Cathedrae and Flexura.

Diagram. A figure in the right margin spanning the lower portion of the page, showing curved meridian-like lines converging toward an apex at the top, with an inscribed configuration of points forming the working triangles of the computation.

- E (apex, top): the pole / vertex point E
- C (upper, within the figure): point C
- A (left of center): point A
- B (right of center): point B
- D (below center): point D
- F, G, H, I (along the base, left to right): the foot-points F, G, H, I

I. Triangle ABE.

(P. = degrees; M. = minutes)

- Side AE: $38^{\circ}20'$ — Complement of the latitude of Lucida Cathedrae [Luc. Cathedrae, Compl. Latit.]
- Side BE: $41^{\circ}0'$ — Complement of the latitude of Flexura [Flexurae, Compl. Latit.]
- Angle ABE: $8^{\circ}50'$ — Difference of longitude
- Hence BA: $6^{\circ}14'$ — found by calculation [Per Calculum inquisita]
- Angle BAE: $111^{\circ}50\frac{2}{3}'$ — found by calculation

II. Triangle [ABC].

(P. = degrees; /. = minutes; //. = seconds)

- Side AC: $5^{\circ}19'$ — between the New Star and Lucida Cathedrae [Inter Novam Stellam & Luc. Cath.]
- Side BC: $5^{\circ}2'$ — between the New Star and Flexura [Inter Novam Stellam & Flexuram]
- Side BA: $6^{\circ}14'$ — as has just now appeared [modò patuit]
- Angle BAC: $51^{\circ}0'25''$

III. Triangle AEC.

(P. = degrees; /. = minutes)

- Side AE: Complement of the latitude of Lucida Cathedrae [Complement. Latit. Lucidae Cathedrae] — as before [vt prius]
- Side AC: Distance between the New Star and Lucida Cathedrae [Distant: inter Nou. Stel. & Luc. Cathed.] — as before [vt prius]
- Angle EAC: $60^{\circ}50\frac{1}{4}'$ — the angle BAC having been subtracted from BAE [ablato Angulo BAC à BAE]
- Side CE: $35^{\circ}59\frac{5}{8}'$ — Complement of the latitude of the New Star [Complementum Latitudinis Novae Stellae]
- Angle AEC: $7^{\circ}54'$ — Difference of longitude from Lucida Cathedrae, to be added [Differentia Longit. à Luc. Cathedrae addend.]

Therefore there results, for the New Star [Provenit ergò, Novae Stellae]: (P. = degrees; /. = minutes)

- Longitude: $6^{\circ}53'$ Taurus [♉]
- Latitude: $54^{\circ}0'$ N [B.]

SECOND [SECUNDO]

From Lucida Cathedrae and Schedir.

I. Triangle ADE.

(P. = degrees; M. = minutes)

- Side AE: $38^{\circ}20'$ — Lucida Cathedrae [Luc. Cathedrae, Complement of latitude]
- Side DE: $43^{\circ}15'$ — Schedir [Schedir, Complement of latitude]
- Angle AED: $3^{\circ}0'$ — Difference of longitude of Cathedra and Schedir [Differentia Longitudinis Cathed. & Schedir]
- Side DA: $5^{\circ}17'$
- Angle ADE: $20^{\circ}24\frac{1}{2}'$

II. Triangle ADC.

(P. = degrees; /. = minutes)

- Side DC: $7^{\circ}50\frac{1}{2}'$ — between Schedir and the New Star [inter Schedir & Novam Stellam]
- Side AC: $5^{\circ}19'$ — between Lucida Cathedrae and the New Star [inter Luc. Cath. & Novam Stellam]
- Side AD: $5^{\circ}17'$ — already found by the operation [per operationem iam inquisitum]

- Angle ADC: $42^{\circ}29'$ — appeared from the triangular calculation [ex Calculo Triangulari patuit]

III. Triangle DCE.

- Side DC: Distance between the New Star and Schedir [Distantia inter Novam Stellam & Schedir] — as before [vt prius]
- Side DE: Complement of the latitude of Schedir [Complementum Latitudinis Schedir] — as before [vt prius]
- Angle CDE: $22^{\circ}4\frac{1}{2}'$ — angle ADE having been subtracted from ADC [Subtracto Angulo ADE ab ADC]
- Side EC: $36^{\circ}5'$ — Complement of the latitude of the New Star [Complementum Latitudinis Nou. Stel.]
- Angle DEC: $5^{\circ}1'$ — Difference of longitude relative to Schedir [Differentia Longitud. ad Schedir, Nou. Stel.]

Therefore it falls [Incidit itaque], in: (P. = degrees; /. = minutes)

- Longitude: $7^{\circ}0'$ Taurus [♉]
- Latitude: $53^{\circ}55'$ N [B.]

THIRD [TERTIO]

From Flexura and Schedir.

I. Triangle DEB.

(P. = degrees; /. = minutes)

- Side DE: $43^{\circ}15'$ — Schedir [Schedir, Complement of latitude]
- Side BE: $41^{\circ}0'$ — Flexura [Flexurae, Complement of latitude]
- Angle BED: $5^{\circ}50'$ — Difference of longitude of Schedir and Flexura [Differentia Longitudinis Schedir & Flexur.]
- Side DB: $4^{\circ}31'$
- Angle EBD: $117^{\circ}39\frac{2}{3}'$

II. Triangle BCD.

(P. = degrees; /. = minutes)

- Side BC: $5^{\circ}2'$ — Distance between Flexura and the New Star [Distantia inter Flexuram & Novam Stellam]
- Side DC: $7^{\circ}50\frac{1}{2}'$ — Distance between Schedir and the New Star [Distantia inter Schedir & Novam Stellam]

- Side DB: 4°31' — as became known before [vt prius innotuit]
- Angle DBC: 110°25' — found by the triangular operation [Per Triangularem operationem inquisitus]

III. Triangle BCE.

(P. = degrees; /. = minutes)

- Side BC: through the distance of the New Star and Flexura [per distantiam Novae Stellae & Flexurae] — these are given [sunt data]
- Side BE: through the complement of the latitude of Flexura [per Complementum Latitud. Flexur.] — these are given [sunt data]
- Angle CBE: 7°14¾' — known by subtracting angle CBD from angle EBD [per subtract. Ang. CBD ab Ang. EBD notus]
- Side CE: 36°0½' — Complement of the latitude of the New Star [Complementum Latitudinis Novae Stellae]
- Angle BEC: 1°5' — Difference of longitude of the same, to be subtracted from Flexura [Differentia Longit. eiusdem à Flexura subtr.]

Therefore there results, for the New Star [Provenit ideò, Stellae Novae]: (P. = degrees; /. = minutes)

- Longitude: 6°44' Taurus [♉]
- Latitude: 53°59' N [B.]

Collection of the longitude and latitude found, from the assumed places of the fixed stars by the Copernican reckoning.

[A summary table, with the three results gathered. The brace at right and the "B." mark the latitudes as northern.]

NAMES OF THE STARS EMPLOYED	New Star Longitude (P.)	(M.)	New Star Latitude (P.)	(M .)
I. From Lucida Cathedrae and Flexura	6	53 ♉	54	0
II. From Lucida Cathedrae and Schedir	7	0 ♉	53	5 5
III. From Flexura and Schedir	6	44 ♉	53	5 9

[The latitudes are all marked northern (B.) by the brace at right. The longitude minutes carry the ♂ (Taurus) sign.]

In latitude, indeed, the difference here is not so very great, since the latitudes of the stars marked in the common tables [in Abacis communibus] do not stray much in the case of these three; and so, as far as latitude goes, the greatest discrepancy comes to at most 5 minutes. In longitude, however, it is three times that — amounting to 16 minutes. As for longitude too: the value first derived from Lucida Cathedrae and Flexura agrees quite well with my own determination, exceeding it in latitude by a quarter of a degree. In the rest the disagreement is larger, as regards longitude, so that my place stands as it were midway, while for the two following longitudes the latitude comes out somewhat less.

By the Alphonsine reckoning the same values come out thus.

(From)	Longitude (P.)	(M.)	Latitude (P.)	(M.)
A: Lucida Cathedrae and Flexura	6	1 ♂	54	0
A: Lucida Cathedrae and Schedir	6	8 ♂	53	55
A: Flexura and Schedir	5	52 ♂	53	59

[The "A" with a brace at left groups the three star-pairings; the longitude minutes carry the ♂ (Taurus) sign; the "B." brace at right marks the latitudes northern.]

The Alphonsine calculation, therefore, falls short of the Copernican everywhere by 52' as regards longitude — as much, indeed, as it sets back the positions of all stars to an earlier point. In latitude, since the same values are assumed for the stars in both cases, the two agree exactly. And from this it is clear that, unless the positions of the fixed stars have first been correctly restored, it is futile to derive from them the precise place of anything else, even if the observations themselves are properly carried out.

Moreover, the place of the New Star by the Copernican reckoning, by a further procedure through the differences of right ascension [per differentias Ascensionales] and...

[The page ends mid-sentence; the argument continues.]

it is fitting to determine the [right ascensions] and declinations here as well. Therefore, assuming here too the same configuration we used above, in the same

manner, and understanding the stars by their designations as before, let the Copernican right ascension of Lucida Cathedrae [Schedir] now be $356^{\circ} 2'$ at point A, and its declination $57^{\circ} 3'$ north at point B. The declination of the star at the extremity of the foot [pedis], at point D, is $28^{\circ} 53'$, and its right ascension at point P is $54^{\circ} 41'$.

It should be noted, however, that this star in the foot of Cassiopeia is very erroneously assigned in all the canons of the fixed stars — so much so that everywhere it falls short by a full sign and three degrees, which seems to have come about through the fault of the copyists. We have therefore restored it to a standard consistent with the others. But to return to the matter at hand.

In Triangle BAC.

		P.	M.
Side [Latus]	BA	32	57
Side [Latus]	CA	28	13
Side [Latus]	BC	5	19
Angle [Angul.]	BAC	4	46

In Triangle CAD.

		P.	M.
Side [Latus]	CA	28	13
Side [Latus]	DA	25	$19\frac{1}{6}$
Side [Latus]	DC	12	59
Angle [Angul.]	CAD	28	$22\frac{1}{2}$

If, then, the prior angle of difference BAC is added to the right ascension of Lucida Cathedrae [Schedir], the right ascension of the New Star that results from this comes to $0^{\circ} 48'$. But if the other angle CAD is subtracted from...

Diagram. A narrow, tall curvilinear figure at the right margin, drawn as a long sliver tapering upward to a single apex. The apex is labelled at top; near the upper-middle, a short transverse segment crosses the figure carrying three labels; the base is a horizontal line carrying three labels.

- A (apex, top): vertex A
- B (left, mid-figure on the transverse segment): vertex B
- C (center, on the transverse segment): vertex C

- D (right, on the transverse segment): vertex D
- E (base, left): vertex E
- F (base, center): vertex F
- G (base, right): vertex G

from the right ascension of the foot [pedis] at point II, it will give the right ascension of the star at P as $0^{\circ} 30\frac{1}{2}'$. It therefore differs from the prior result by $17\frac{1}{2}'$, half of which, added to the smaller right ascension, yields a limited right ascension for the New Star of $0^{\circ} 39'$.

To this right ascension and the declination indicated earlier, $61^{\circ} 47'$, if we adjust the longitude of the same as was done before, the following will result in the same figure:

Diagram. A circle (a spherical-triangle / great-circle construction) with several chords drawn across it intersecting at interior points. Vertex labels are placed around the circumference and at interior intersections.

- A (top of circle): vertex A
- B (upper left, near circumference): vertex B
- C (interior, upper-center): vertex C
- D (interior, right-center): vertex D
- E (interior, lower-center): vertex E
- F (upper-right, outside the circle; lead-letter of the side/angle table's first row): vertex F
- G (interior, lower-center, immediately to the left of E): vertex G
- H (lower-left circumference point): vertex H
- I (left circumference point): vertex I
- K (right edge, outside the circle; lead-letter of the side/angle table's "Angul. BAC" row): vertex K

[Margin: Latitudinem] (a marginal gloss "Latitudinem" appears above the line near "Longitudinem")

		P		
		.	'	
Side [Latus]	BA	2	$31\frac{1}{2}$	Maximum Declination [Declinatio Maxima]
		3		
Side [Latus]	CA	2	13	Complement of the Declination of the New Star [Compl. Decl. Nou. St.]
		8		

		P		
		.	'	
Angle [Angul.]	BA	9	39¼	added to the right ascension to make 90
	C	0		[addita Asc. R. ad 90]
Side [Latus]	BB	3	19	Complement of the Latitude
		6		[Complement. Latit.]
Angle [Angul.]	AB	5	58	Difference of Longitude from ☊
	C	2		[Different. Longit. à ☊]

If, then, the angle ABC is counted forward from the Tropic of Cancer ☊, the longitude of the New Star will fall at 7° 28', and its latitude, from the complement BC, at 53° 41'. Although these do not differ much from our own determination of the star's place, that comes about rather by accident, and because of the limitation applied, than because the places of the stars are properly constituted. This was made sufficiently clear in the right ascensions verified in turn, which differed from one another by nearly 18 seconds [scruples].

If one wishes to draw the Alphonsine places of the stars into use in the same way, the right ascension of Lucida Cathedrae [Schedir] will come out as 357° 25', and that of the other star in the foot as 359° 22'; so that the difference is 2 degrees less at least three minutes — which is truly excessive. The mean of the two gives a right ascension of 258° 23½'; and this, applied to the customary declination, yields, by the preceding demonstration, the angle ABC as 54° 18' — namely, by how much the New Star would have to be moved from the beginning of Cancer ☊ backward, so that its place...

by this reasoning is at 5° 42" — falling short of the truth by more than a full degree — and the latitude at 54° 25', nearly northern [Borea], exceeding by two-thirds of one degree; which deviation in both cases is indeed excessive. But let this suffice concerning these matters.

I have added, moreover, the places of the New Star as they emerge in different ways according to the Alphonsine and Copernican computation — not because these contribute anything of solid weight to the matter I intend, but so that the disparity might be more readily recognized, and the necessity of correcting the fixed stars (as we said) might be perceived; and so that it might at once be evident from these how easily those have lapsed into error who, presupposing the Tables, have relied on the stars by their numbers with no correction applied. Hence it is no wonder that the places of this star have been so variously predefined by

various authors, and that even if the distances observed from those stars had been sufficiently congruent, yet in part they are not a little wanting.

Setting aside, therefore, these erroneous and discordant results, we shall retain as established and beyond doubt the true and exact place of the star, confirmed above by us in many ways — which is also throughout in close agreement with itself. Thus the longitude of the star will be set at $6^{\circ} 54''$, with a latitude of $53^{\circ} 45''$ north [B]. The right ascension arising from this is $0^{\circ} 26'$, and the declination about $61^{\circ} 47'$. And the meridian altitude of the heaven, in the ecliptic, coincides with $0^{\circ} 29' \text{ } \text{V}$ [Aries], just as it was previously set out by us in the same manner. These were the things we set out to investigate and demonstrate in this Caput.

It should be known, moreover, that the place of the star designated in this manner — even though it proceeds from the surface of the Earth — is nonetheless the same as the place that proceeds from the center, since there was no difference of the true and apparent place, so that to inquire into this carefully is not worth the effort, as will become manifest from what will be demonstrated in the following Caput.

CAPVT SEXTVM.

On the Situation of this Star with respect to the Diameter of the whole Universe: whether it stood in the Elementary Region, or rather in the Ethereal, and in what part of it.

To predefine the very place of this New Light [Iubar] so exactly, with respect to the ecliptic and the equator, that not even half of a single scruple should lie hidden anywhere short of it or beyond it — just as was accomplished by us in the preceding Caput — even if it is wrapped in not a few difficulties, and is not attained unless the instruments and observations have been kept to the utmost precision, and unless, moreover, the assumed places of the fixed stars have first been accurately verified, so that no ordinary diligence is required in carrying all this out properly: that, nevertheless, which we now undertake — namely, to recognize with certainty and to demonstrate evidently the remoteness of this star from the Earth, and in what part of the Universe it shone forth — is of far greater effort, labor, and subtlety, and is more arduous and exposed to a greater number of the windings of difficulty.

But where the keenness of the human Mind does not reach, Geometry and Arithmetic — used as if they were spectacles [perspicilia], rendering the eye sharper, and by which, equipped as if with wings, it flies up into the most remote

Ether and the innermost recesses of the Heavens — extend. We therefore, relying on these aids as well, and applying that which was tested upon the external senses, whether by themselves or more accurately by suitable instruments, shall undertake to investigate the situation of this Star with respect to the diameter of the Universe, and to demonstrate it by undoubted proofs [Apodixes], and to persuade of it free from all suspicion of error [hallucination].

The chief and most important questions that arise about this Star concern its situation: whether it was placed in the elemental world below the Moon, or rather in the heavens within the orbits of the seven Planets, or even above them among the fixed stars themselves. These are the things to be examined.

I am well aware, of course, that for several centuries now a certain philosophy has been approved and has resounded everywhere through the Schools (or rather, I should almost say, has been mouthed under a mask) — taken for granted and admitted without question: that within the bounds of the heavenly world nothing new can ever appear that is not coeval with the heaven itself and, as it were, born together with it. For (so this view holds) no region of the ethereal world can take on the instability of generation, corruption, or any sort of alteration — nothing foreign to its nature; rather, all these belong solely to its elemental part, confined within the circuits of the Moon. On these grounds it might seem, to those steeped in this long-standing philosophy, both quite superfluous and strangely bold to place this Star beyond the limits of the elemental region, within the enclosures of the heavens, or to hesitate at all over whether it lay below the Moon. For those imbued with the teaching of Aristotle [Aristotle] and the Peripatetics — men who have filled almost every lecture-chair of the universities with their prejudices — do not for a moment doubt that this is exactly how one must think; so much so that they would rather meet anyone who maintains the contrary with mockery, or with outright dismissal alone.

And yet, things that have been approved over a long span of time and have struck deep roots through the authority of distinguished men do not on that account always stand entirely and rightly; the truth sometimes lies in the opposite direction. For Nature is an unfathomable abyss, and the human mind — especially in the great many matters set so far apart from the external senses — very often gropes in the dark and stumbles. Now the nature and condition of the heavens has, until now, been transmitted in the Schools of the Peripatetics in a way that is less than accurate, and much of it, far removed from its true essence, has been imposed upon us in obscurity. This will become perfectly clear both from what we set out plainly throughout this whole work concerning the more

recent phenomena, and, more particularly and especially, from those things that I demonstrate in the present Book — indeed, in this very Chapter — concerning this New Star.

That this recently observed Star shone forth not only within the very confines of the heavenly world, not merely beyond the lunar regions, but above the orbits of all the Planets as well, and so within the loftiest theatre of the fixed stars — this will be made abundantly plain from what follows. There, by a fourfold line of reasoning, I shall establish beyond all doubt that this was so. I shall do this first by a general consideration, drawing out and displaying the things that could be discerned about this Star by external inspection alone. Afterwards I shall confirm, by more particular and more subtle Geometrical Demonstrations, that the matter is wholly free of doubt.

That this New Star blazed forth in no way in the elemental world, but far above the Moon, and above all the other Planets, in that sphere which men call the Eighth — this is what I now infer in general terms from those things that lay open to view in it by sight alone.

COMPROBATIO PRIMA. [First Proof]

That this Star had nothing in common with the elemental and sublunary Meteors was plainly proved by its very appearance and majestic Form, which was utterly like that of the other stars shining in the heavenly world. For when has any fiery Meteor — whatever, in the end, it may have arisen from — ever been read of as having stood in the likeness of some genuine star, so as to differ in no respect from its appearance?

For as to the torches of falling stars (as they are called) that we see, even though from the first they may put on a certain light that rivals that of true stars, nevertheless, falling suddenly toward the Earth, they display a rather elongated trail, since the matter in which they were burning tends downward; and this trail is very often found even after their light is extinguished. Such Meteors as these, and the like, are therefore wholly irrelevant here.

So too with the Star that appeared to the Magi: even though it preceded them through the Air not far above the Earth, and was doubtless not unlike the other Lights of the heaven, nevertheless that it was a peculiar Portent of God, shown to the Magi by his singular grace, and not to be counted among natural things, however miraculous — this I have already argued earlier, and so I find no place for it here either.

Much less does that Torch belong here which for a whole year stood over Jerusalem in the likeness of a sword, foreboding ruin; for by its very form it displayed a great difference from the stars.

Nor, indeed, have any of the Comets ever been observed with an appearance closely resembling the stars themselves. For granted that they too in no way lie below the Moon (as the cleverness of the Peripatetics, and a plausible conjecture, has so long imposed on us by having them coalesce there), but really move about in the Ether itself — as in the following two Books I shall most clearly prove, concerning those Comets that have appeared in recent years, once all the obstacles that could be brought against the contrary view are removed — nevertheless, even though these very Comets share in the celestial Nature, they do not present the appearance of stars coeval with the heavenly world; rather, with a duller and dimmer countenance they grow faint. And for this reason I conjecture that they have been declared by the Ancients never to be seen at the western cardinal point of the heaven, because their Light is not so bright and strong as that of the other stars, and being weaker in penetrating power, it is more easily intercepted and obscured by the vapors that are multiplied and condensed about the Horizon than is the case with the other heavenly bodies. The very Figure, too, in which Comets present themselves to be seen marks a great dissimilarity from the rest of the stars, and likewise from this New one. For all Comets either extend some Hair or beard out lengthwise, or spread it all around — unless they pass close opposite the Sun, where that Tail is raised upward and turned away from our line of sight, or unless they are too far distant from us, so that the fineness and rarity of their Hair is withdrawn from view.

For all these reasons, then, since this new Phenomenon, as regards its external appearance, represented by no marked resemblance either all the fiery Meteors of the sublunary Region or even the Comets that run their course among the heavenly bodies, but proved entirely conformable to the genuine stars themselves, it follows reasonably enough that it is to be placed neither in the elemental Air nor in the fiery Element (supposing this deserved any place below the heaven, in whose track fiery Meteors are generated), nor yet within the vast expanse of the heaven where the seven Planets carry out their ordinary and perpetual revolutions — the very place where the slightness of the Parallaxes of Comets, and their exhibition of a proper motion, sufficiently testify that the Comets too must be set — but is to be raised far more sublimely, up to the very deepest Seats of the fixed stars.

In its light, too — clear, pure, and radiant — it perfectly imitated the genuine stars of heaven, and it had nothing in common with the duller, fainter light of the sublunary meteors or of the comets. For this reason it far surpassed the seat of the meteors and of the comets, and therefore it necessarily took its place among the fixed stars. That comets can be generated within any region whatever of the secondary moveable bodies [secundorum mobilium], even out as far as the revolutions of Saturn, the highest of them — this will not turn out so incredible or absurd as it has hitherto seemed, as I shall set forth in the books that follow.

This star also possessed a plainly celestial color, so much so that no one could ever produce its like without there being seen in the heavens themselves some star very similar to it and endowed with the same color. From this too it is wholly consistent that the star claimed for itself a place among the heavenly bodies.

Nor does the fact that it varied in color, and did not display the same color constantly throughout its whole duration, as the rest of the stars do, prove well enough that it should be withdrawn from the celestial world and placed among the elementary things — even granting that such changes of color happen more readily here. For that alteration occurred by accident, according to whether the star's body was larger, more compact, or more slender; and indeed this change accompanied the change in its visible magnitude. But how the fact that it underwent no decrease in its apparent size could be sufficient to banish this star from the heavens, I shall discuss later.

Its scintillation, moreover — exceptional, and sparkling beyond the other lights of heaven — showed most plainly of all that it had chosen its place within the highest and vastest region of the fixed stars, and that it surpassed the orbits of all the planets, let alone the lowly elemental world.

For no sublunary meteor sends out a scintillating, quivering light; indeed not even the Sun and Moon, nor any of the other planets, properly possesses this — only the fixed stars [Affixis Sideribus], and it belongs more peculiarly to some of them, less so to others.

For although the Sun and the planets sometimes appear to scintillate a little, this happens only by accident, through the interposition of some medium in the air that is less pure and is agitated this way and that. Hence too it is seen to happen not always — indeed only very rarely — whereas with the fixed stars it is perpetual and customary. Why the fixed stars always scintillate, but the wandering stars [Erraticae] do not, the writers on optics give as their reason — as it is set out, for instance, by Witelo [Vitellio], Book 10, prop. 55. He maintains,

namely, that it happens through a certain divarication of the light, on account of the elements of air and fire interposed (for that there is fire beneath the heavens, trusting Aristotle too far, he concedes), which, as much by nature as by accident, perpetually waver this way and that and come between the forms of the stars and our sight. For when the transparent medium [Diaphano], through which the light of the stars is seen, is moved, that light is observed to be as it were scattered and made to quiver this way and that, and on that account to force this scintillation upon the eyes — just as, if their image is seen in clear flowing water, it shimmers all the more, on account of the onrushing current of the water, into a tremulous scintillation. To the question why this happens very rarely in the planets, he adds this reason: that they are nearer to our sight, and therefore their forms reach our view more strongly, and however much the interposed transparent bodies are moved, they penetrate more readily, without distraction and divarication. And when the planets are nonetheless thought sometimes to scintillate, this comes about by accident, when certain watery vapors thicker than air, agitated this way and that, intervene. And so the Sun too sometimes, especially

in the spring season, when the pores of the earth open and exhale more vapors, is reckoned to scintillate toward the east and as it were to move in its own form. And from this comes the popular belief that the Sun, rising on Easter Day, as it were dances in a circle — when this can in fact be seen not on that day alone, but rather on many days, chiefly in the spring season, into which Easter falls every year, more or less according to the disposition of the vapors lying between.

Nevertheless, whether this resolution by the optical writers concerning the scintillation of the stars deserves approval in every respect raises no slight doubt — since Saturn, being in its apogee [Apogaeus] and most remote from the earth, and approaching very near to the seat of the fixed stars (unless one chooses to hold with Copernicus that an enormous emptiness still lies between Saturn and the fixed stars, deprived of stars, which is absurd), nevertheless never, or only very rarely, admits scintillation; so much so that it happens rather to Mars and Venus and Mercury, which are much nearer to us — whereas it would be more fitting, according to these reckonings of the optical writers, that Saturn should send out its rays somewhat more, or at least more often than the others, on account of its greater distance [elongation]. Yet the contrary of this is what comes to pass.

Nor do I see why the star in the mouth of the Dog [Sirius], the largest and brightest in form and light, does not reach us as forcibly as that star of Mars when Mars is more remote from the earth and is seen not much larger than the

stars of the third magnitude. For the nearer Sirius [Canicula] is to us at such a time, the smaller it appears, and its light does not so strike our eyes as does the said star of Mars. So that even though Sirius, being more remote, is raised at least somewhat above the orbits of all the planets,

it nonetheless sends to us a stronger and greater light, because the interposed transparent bodies that produce the scintillation penetrate more forcibly, without hindrance and divarication. Nevertheless Sirius scintillates by far the most of all the fixed stars, whereas the star of Mars [Martia] by no means does — or certainly very little and very rarely. And so with the rest. These speculations of the optical writers concerning the cause of scintillation plainly suggest that they do not entirely settle the matter, nor sufficiently guard against the several objections.

It can therefore be that the very thing which certain of the ancient philosophers supposed is not so far from the truth of the matter — namely, that the fixed stars perpetually rotate about their own centers, and so, by this motion appropriated to themselves, produce some divarication in the intermediate air for those who behold them. The planets, by contrast, do not revolve about their own centers (a sign of which is that the spots of the Moon are not always seen alike upon it), but are intent only upon their circular motion along their circumference with respect to certain centers, and so are not subject to these accidents of scintillation — except insofar as it sometimes comes about through the interposition of vapors fluctuating in thickened air; and even then it does not last longer than that vaporousness is dissipated.

But that scintillation occurs in the fixed stars not merely on this account — that their light is made to quiver toward us through the motion of the air (to say nothing of the fiery element, which is a fiction) — but also for this reason: that, since the form of the stars passes through to us across a vast heaven revolving perpetually and most swiftly in its universal circuit, it is probable [that the scintillation arises thereby]. For although the fixed stars too are carried around together with the heaven, nevertheless, on account of the continual motion of the intervening transparent medium, and by the diverse agitation of the interposed air, their light toward us

it strikes the eye with a kind of vibration and divergence. Why this same effect is not everywhere observed in the case of the planets remains, even now, unexplained — unless (as I said earlier) we are willing to grant that the fixed stars spin in circles about their own centers, while the wandering stars do not.

Hence some stars scintillate more, others less, according as they intensify or slacken that revolution.

But whatever the cause may be — why the fixed stars vibrate with a perpetual scintillation, while the planets very rarely do (a point I do not now intend to settle) — this much, at any rate, must in fairness be admitted without any evasion. This new star, by its continuous scintillation, which persisted as long as it was visible, did not merely imitate the fixed stars but surpassed them in this vibration of light, especially at the outset. Therefore it did not lie within those bounds of the heavens enclosing the revolutions of the seven planets, but was set among the most remote of the non-wandering stars [fixed stars]; and so it was subject to this affection of scintillation in the same way they are.

Furthermore, its immobility — by which it perpetually remained in the same place in the sky, like the rest of the fixed stars — gave sufficient testimony that it held that seat in common with them. For the comets, too, even though they move in the aether (yet below the eighth sphere), have been found always to possess a certain motion of their own, and never to stay long in any one place. This is because they are positioned within the tents of the planets [intra Planetarum tentoria] and so try, in their own fashion, to imitate the planets' motions as well — now slower, now sometimes faster — according to the particular power of motion implanted in each,

from whatever cause, in the end, that power may arise, whether external or internal.

That this New Star, moreover, conformed so exactly to the universal motion that it expressed it most perfectly — neither in any way going against it, nor lagging behind it, as happens in the planets and comets except when they appear stationary — this proves that beyond all these, right up to the fixed stars, it shared in the daily revolution as well, and with an observance so steadfast and scrupulous that it must be ranked at the highest level. Unless, perhaps, I should be willing to agree that this universal motion takes place in the Earth, as Copernicus and certain of the ancients held — which, however, I shall in no way concede in point of actual truth, and which I shall amply make clear elsewhere. Indeed, even so a reason would have to be given why this star obeyed the daily motion so aptly, even if that motion were in the Earth, and did not disturb it in the least by any departure of its own.

Copernicus, for his part, holds that the highest air below the orbs of the Moon is motionless, and that at least the part of it adjoining the Earth is carried around

together with her by a kind of concomitance; and accordingly he supposed — seduced here too by the doctrine of the Peripatetics — that comets in that air, besides their own motion, also appear to be swept around in the daily circuit every 24 hours.

Aristotle, by contrast, held that the highest air, together with the sphere of fire produced by itself, lies adjacent to the seat of the Moon and is whirled around by the speed of the celestial spheres (which he wrongly supposed to be real bodies attached to the heaven). For certain reasons I would not believe that either of these views is entirely correct. But let it be whatever one pleases: whether the upper air moves or not, it could in no way have carried this star along so uniformly — had the star been there — as to take nothing away from the prime motion nor add anything to it, and least of all for so long, beyond the duration of an entire year. Nor, in that air, were it motionless,

could any meteor representing a star have held together so firmly for so great a time, seeing that it would be made of fiery matter, inconstant and shifting, established in an element subject to fluidity itself. And if we were to place it within the circuit of the planets, no resting place will be granted it, right up to the outermost revolutions of Saturn. For wherever it be placed, the annual motion of the Earth according to Copernicus will not permit it to remain fixed under one place of the sky, since — by the shifting of parallax [commutatione Parallaxeos], just as in the other five planets — through the Great Orb [Orbem Magnum] arising there, it would be displaced into one position after another, as the Earth departs hither and thither; so that, even if the star were allotted no proper motion of its own, it would plainly appear, even on this hypothesis, that this star of ours could find no place in the diameter of the world where it might come to rest in the manner of the fixed stars, unless it were lifted up to their very level.

And so, by its lack of proper motion, by the exquisite concomitance of the daily revolution, by its sparkling scintillation — all of which it held in common with the fixed stars — it could very well stand, indeed be brought into line, with these Copernican calculations too (which, however, I shall show elsewhere to be discordant).

Its duration, besides, so long-lasting that it endured through a whole year and at least a third part beyond, gave sufficient witness that it did not exist in unstable sublunary matter and place. For there, whenever meteoric bodies arise that display a certain brightness, they cannot last very long. Whatever burns seeks fuel, and cannot subsist long in a single consumable matter such as the elemental

kind, but once that matter is consumed it ceases to be seen as it flames out. Thus the comets too, although in truth they do not consist of elemental matter,

nor yet are they generated below the Moon, but in the celestial world, and indeed out of celestial matter — as I shall plainly disclose in the later books, where I intend to treat of these matters expressly — were anciently found to have been allotted a minimum term of duration of seven days; while Pliny [Plinius] records the longest to be 80, though some maintain that as many as a hundred should be reckoned, so that there would be 180 days to be counted. And so six months, or half a year, would suffice for their longevity — which is the more probable view. For no comet is described in trustworthy histories that has exceeded this time; and those that in an earlier age were seen by Regiomontanus, Fracastoro [Fracastorius], Apian [Appianus], and Gemma Frisius in no way reached this span. Nor have any of those that we ourselves have hitherto seen persisted so long. The longest-lived was the one observed in the year 1577, of which I shall treat in the book that next follows — and yet it did not fully complete three lunar months, which is half of that span, the very longest duration attributed by the ancients to the most enduring.

Therefore, since this recent star lasted nearly threefold beyond the customary period of comets, it is reasonable that it was raised above their common lot, and so also above their place — that is, not within the gyrations of the planets, where comets move, but in a region still loftier, namely the firmament of the non-wandering stars, where it remained steadfastly fixed for so long.

A plausible objection, indeed, may here be raised: from the fact that this star altered both in magnitude and in color in succession, until at last, wholly consumed, it disappeared — as though for this reason, in that immutable theater of the celestial region, nei[ther]...

that it existed not even in the region of the planets, much less in the still higher region of the fixed stars, but rather shone forth in the sublunar air, which is suited to such inconstancies and changes. To anyone trained in the Aristotelian school, and content with that alone, this line of argument might well seem reasonably probable. But the truth is far otherwise. For there is no necessity that all the visible bodies of the world which, since the world was first divinely formed, sometimes arise miraculously and contrary to the ordinary laws of nature, should also endure forever and await the final dissolution of the world. On the contrary, just as they came into being at some midpoint of time once it had begun, so too it is altogether fitting that, before the consummation of that time whose clock is set within the celestial machine, they should reach their end.

Whatever exists outside the ordinary laws of nature is likewise not subject to those laws; rather, it completes its own course apart, by its own measure, and does not last very long. We see the same thing even in those things that are produced as monstrosities in this lower realm of nature: they do not persist for long, and they never attain the term that nature has naturally fixed for the other things they seem to imitate.

It would be more remarkable, then, that an alien star should have stood firm and endured unchanged in the highest aether, for more than a whole year, amid so great a commotion of the celestial world and as though by the powerful force of the solar and stellar light — than that it should have ceased to be by gradually diminishing. For it is not likely that it was formed of matter so dense and so exalted toward constant perpetuity, and composed in the same way as the rest of the stars, that on that account it should have undergone alteration and consumption little by little — just as we see...

happen in metallic bodies engendered within the bowels of the Earth, which are in large part analogous to those celestial ones: some, like purified gold and silver, withstand the prolonged violence of fire, while the rest, being of less worth, are consumed by it and pass off into smoke — and this sometimes more quickly, sometimes more slowly. For although all things consist of one and the same primal matter, that matter is not equally arranged, ripened, and graduated in each individual case.

There is therefore nothing new in it, if something new appears in the heavens beyond the common course, and it follows that this same thing does not grow old there — provided that it was not brought to completion in a way conducive to the perfection of the rest of the celestial bodies and of the world itself. So too, the fact that it changed color from time to time is of no consequence; for if the creation of an extraordinary body in the heavens is itself miraculous, this too can easily be granted as well.

Indeed, on account of its change in magnitude and the decrease of its light, it necessarily also had to alter its color, since it did not everywhere persist in the same quantity and compactness of body. Its very appearance, presenting a greater or lesser light, contributed something to this — especially because of the disposition of the intervening air, which was not the same in all places and at every time. The keenness of sight, too, differing in some observers from others, suggested some discrepancy. And from this it came about that in widely separated places, even at the same times, the tincture of color was not noted by different observers as exactly the same — indeed, not even in one place and at

one and the same time was it always the same to several observers. Nevertheless, the universal change that occurred with respect to the differences of color we have carefully indicated in the preceding chapter. And this change it did not display in a haphazard or confused manner, but altered it gradually in proportion to the change of magnitude — and that slowly, and only after much time had elapsed in between...

so that it was possible to discern this distinction. Hence it is also clear that no elemental inconstancy — which suddenly seeks out varied forms and tinctures — was present in this star, or at least follows from that.

Nothing, therefore, prevents this newcomer star [Neotericum Sidus] from having blazed forth in the very aether itself, indeed at its supreme summit, near the fixed stars — as is shown by the fact that it displayed its magnitude and color gradually waning and growing thinner, until it ceased to be altogether.

Nay, I will say something further: this star was at the outset most like the others coeval with the world, and it vied with them in the resplendent majesty of its form and light, even surpassing most of them, so that you would say it differed in nothing from the genuine stars — indeed, that it was more excellent than they. Yet none the less it gradually disappeared, diminished both in quantity and in light, less than a year and a half from its first rising. In the same way all the remaining stars, however coeval with the world, and however long it lasts, are subject to change, and at last, when the universal consummation of all things arrives (as we hinted briefly above), are likewise to be dissolved. This the star rather prefigured, and as it were displayed by example, than that we should contend that for that reason it was not in the heavens. For Aristotle's philosophy cannot admit this, since this philosophy ought rather to be corrected from such evidence than to prescribe laws to the heavens, or to the Creator himself. And from this single star alone, all that the Stagirite [Aristotle] fashioned — as falsely as impiously — concerning the nature and eternity of the heavens, and persuaded very many to hold true, is convicted of being utterly void and empty.

These were the things that could be gathered from the general consideration of this star, such as could be had by mere observation — namely, its Form, Light, Color, Scintillation, Immobility, and Endurance — by which its nature and constitution were shown to be in no way elemental...

but rather to belong to the very highest aether, and indeed to have claimed for itself a seat above the orbs of the planets, in the eighth sphere (as they reckon it). This I was undertaking to establish in a broader manner. But if anyone requires a

more particular and more subtle proof, drawn from certain observations — geometrical demonstrations — let him look into what follows, and there (as I hope) he will obtain his wish.

That this strange star [Stella Peregrina] blazed forth neither below the Moon nor within the orbs of the planets, but in the supreme firmament of the fixed stars, is proved by its distances — which it exhibited, with respect to certain fixed stars near which it passed the meridian — by careful observation carried out both at its greatest and at its least altitude.

COMPROBATIO SECVNDA. [Second Proof]

That very same thing which we have just now laid open by a general induction, I shall demonstrate geometrically from certain observations — so that those who, to gratify Aristotle and the Peripatetics, might perhaps presume to evade the foregoing by whatever fabricated subterfuges, may be rendered mute and stupid; and that, not knowing which way to turn, they may find no place here for slipping away. Provided only that they do not, with frivolous boldness, reject the indubitable observations which are here assumed as principles, and that — rightly understood — they grant the geometrical demonstrations resting upon them (which no one endowed with common sense has hitherto attempted to overthrow), so that some among those who long ago played the philosopher, when they asserted that all things proposed and handed down by men are uncertain, and that nothing is so firmly established that it cannot be called into doubt and the contrary maintained — those men, I say, were rather crafty sophists than philosophers; for when it came to geometrical de...

[when] they arrived at these demonstrations, there they came to a halt and fell silent, and seeing that no foothold for contradiction remained, they rested content with these alone.

We, by contrast, hold that nothing whatever should be said against those who set out to disparage and tear down—whether through ignorance or deliberately, or out of some malice and hatred of the truth, or from love of the ancients—the observations themselves taken here as principles, and the geometrical demonstrations subject to no doubt. Let them delight in their vanities and errors, those who refuse to recognize what truly is, and who, blind in the darkness, are pleased with the very darkness they sit in—who neither will nor can look upon the Light of Day. Truth abides unmoved in itself, whether men attain it and approve it or not, and in the end it triumphs. But now to the matter we proposed.

To measure the distance of any celestial phenomenon from the Earth, and to demonstrate it, requires great subtlety; nor can it be accomplished except by means of the Earth itself, on whose surface we move. For although the Earth is small in comparison with the heavenly bodies—since there are very many stars in the heavens many times larger than it, and compared with the firmament it turns out to be utterly imperceptible and of no proportion whatever—nevertheless, however small it may be, given that its circumference contains at least 5,400 of our German miles, and its semidiameter scarcely 900 miles, this very semidiameter still grants us the means of defining the distance of the heavenly bodies, provided they are not removed beyond measure.

For when some object set on high is conceived as sighted in a straight line at once from the surface of the Earth and from its center, it does not show the same place under the Eighth Sphere in both cases. Rather, these two

visual lines, intersecting each other, produce a certain angle that exhibits the difference of aspect between the surface and the center of the Earth (which the Greeks call παράλλαξις [Greek: parallax]). The greater this angle is, the nearer the observed object comes to the Earth; the smaller it is, the more distant the object proves to be—until, with this angle vanishing entirely through its own minuteness, the distance is rendered immense and beyond all proportion. This is exactly what happens, absolutely, in the Eighth Sphere among the fixed stars. For to gather from the Earth's semidiameter how far the fixed stars are removed from us is impossible, since there the semidiameter does not attain a magnitude that strikes the senses; yet that they lie above the revolutions of Saturn—however far distant they may be—is established well enough from the laws of the motions.

It is true that this measuring of parallaxes and distances scarcely finds a place among the three superior planets, on account of their enormous remoteness from the Earth, which renders this difference of aspect quite small—especially in Saturn, where it scarcely exceeds a third part of a minute. Nevertheless, with a most exact instrument that resolves even some small fractions of a minute, it will be possible to test these parallaxes as far as can be done—especially in Mars, when it is acronychal [Acronychius]. I have several times carefully and precisely measured the parallaxes of Mars around that time, in order to establish whether, when it is "all-night," it is brought nearer to the Earth than the Sun itself, as both the Copernican [Copernicus] and our own hypothesis require. At a more fitting place, therefore, I shall make plain what I have found.

In the Sun, by contrast, those parallaxes are not altogether imperceptible, since near the horizon they amount to three minutes. Although in this matter its distance from the Earth is

more readily and surely ascertained through lunar eclipses, as has been the practice of the experts; and indeed from this its parallaxes are rather to be derived conversely—parallaxes which my instruments have very often shown me to agree with the observed values.

So too in Mercury and Venus, when they approach the Earth, to attempt this would be wholly superfluous, unless they were then very close to the Sun, which would shut off any convenient opportunity for the observation.

In the Moon, however, the disclosure of parallax is of all the most notable, because, being nearest to the Earth, it bears a strongly perceptible proportion of distance to the Earth's semidiameter—so much so that it sometimes admits parallaxes greater than a whole degree, as we shall later prove by experiment.

We therefore, in the case of this Star, applying the Earth's semidiameter, shall test whether it has exhibited a parallax to be set on a par with the lunar distances—so that it may be established whether it stood next to or below the Moon in the Elementary World, or rather above it in the Aethereal. We shall likewise make the attempt at the distance of the Sun, to see whether it was higher or lower than this. Indeed, we shall not leave the matter untouched even with respect to the loftiest Saturn. For in this way it will be made plain at what place of the World's Diameter this Phenomenon was set.

By means of the stars, then, with which it almost crossed the meridian—the thing we mentioned—we shall now make the approach.

From the things we recounted in the preceding chapter concerning the observations of this Star, as regards its distances from the neighboring stars of Cassiopeia [Cassiopeia], it is clear that from Schedir, with which it almost crossed the meridian, it stood off by 7 degrees 50½ minutes. From the head [Caput] of the same constellation, however,

10 degrees, 22 minutes, with which it crossed the meridian a little more precisely. So likewise with the Pole Star [Polaris], from which it was removed by about 25 degrees, 14 minutes.

These distances from the aforesaid stars it kept everywhere—both when it ran across the meridian together with them near the vertex above the Pole, and also below, when, passing toward the north, it approached the horizon; so exactly in

each position did it express the same intervals, that, the Star being centrally collimated, the same distances were discerned here as there, and they neither lost nor added anything at all of their visible quantity in the sighting. And so that the testimony of the matter might stand out more surely, and that no suspicion might be raised that some error was tacitly creeping in through a fault of the instrument, I often kept the same angle of the instrument fixed unaltered by its screws from one transit of the Star across the meridian to the other; and thus, with the measuring angle remaining unmoved, I observed exactly the same mutual arrangement of the stars both above and below the Pole, and the interval precisely the same. This could in no way have happened if this New Star had been subject to even the least trace of parallax.

So that it may be recognized still more readily what differences of distance it would have displayed if it had stood next below the Lunar Orb, or even just above the Solar (in the supreme Sphere of Saturn these are imperceptible), we shall test the point by the indication and demonstration of the following diagram, thence resolved into numbers.

In this

Diagram. A large geometric parallax construction filling the page. The outermost circle represents the meridian of the eighth (outermost) sphere. Two perpendicular diameters cross at the center: the vertical line **B–A–D** (the vertical, or zenith–nadir line) and the horizontal line **E–A–C** (the horizon). Concentric with the outer circle are an inner circle and a small central circle around the center point. In the upper-right quadrant a set of dotted arcs and straight rays carry the labels of the heavenly bodies tested for parallax (Moon, Sun, Saturn) together with star-symbols marking the apparent and true positions of the New Star. The leading explanatory sentence below the figure ("In this figure B C D E represents the meridian...") keys the labels.

Readable labels (with positions as drawn):

- **B** (top of the vertical diameter): upper terminus of the vertical line.
- **S** (just right of B, marked with a star-burst): apparent place near the zenith circle.
- **A** (center of the whole figure): the center of the universe and of the Earth.
- **D** (bottom of the vertical diameter): lower terminus of the vertical line.
- **E** (left end of the horizontal diameter): horizon, west.
- **C** (right end of the horizontal diameter): horizon, east.

- **F** (on the inner circle, upper part, just left of the vertical line): point on the inner circle **F I K L**.
- **G** (on the inner circle, just right of F): the New Star's upper meridian position on the inner circle.
- **H** (on the inner circle, lower-right): the New Star's lower meridian position on the inner circle.
- **I** (right end of the inner circle, on the horizon line): point of inner circle **F I K L**.
- **K** (bottom of the inner circle, on the vertical line): point of inner circle **F I K L**.
- **L** (left end of the inner circle, on the horizon line): point of inner circle **F I K L**.
- **N** (above the central small circle): the supreme (highest) surface point of the Earth.
- **M** (within the small central circle, upper): point of the small circle around the center.
- **R** (within the small central circle, near center): point of the small circle.
- **O** (within/right of the small central circle, on the horizon line): point **N O P Q** of the Earth's circumference.
- **P** (below the central small circle, on the vertical line): point **N O P Q** of the Earth's circumference.
- **Q** (left of the central small circle, on the horizon line): point **N O P Q** of the Earth's circumference.
- **β** (Greek beta, upper right, in the small lens/oval near the star-burst): the New Star's apparent upper position seen from N. [Confirmed under magnification.]
- **ρ** (script rho with descending tail, immediately at the star-burst inside the lens): Polaris' small circle marker (prose "ρ γ"). [Confirmed under magnification.]
- **α** (script alpha, below the star-burst in the lens): the Pole of the World. [Confirmed under magnification.]
- **Y** (Latin capital Y, on the topmost dotted arc, upper-right of center): the New Star revolved into "η Y Z". [Confirmed under magnification.]
- **[?]** (a stand-alone glyph the prose calls γ, upper right, in the small lens/oval): not separately legible at this position as drawn — the oval's legible glyphs are β / ρ / α.

- **[?]** (a glyph the prose calls **δ**, upper right, near a star-symbol): not independently legible in the upper-right cluster.
- **ε** (Greek epsilon, on the dotted arc between the inner lens and L): position marker. [Confirmed under magnification.]
- **η** (Greek eta, lower right, on a dotted arc descending to the right horizon, near a star-burst): the New Star's lower position seen from N.
- **[?]** (a glyph the prose may call **ϳ Jupiter**, along the upper-right rays): no glyph on the figure is confirmable as **ϳ** — the "4"-like mark near G is ambiguous between **ϳ Jupiter** and capital Z / ζ.
- Four genuinely-ambiguous hooked glyphs remain flagged **[?]** in the crowded upper-right cluster: the outer-arc hook (far upper-right, between **♄ Saturn** and Z / ζ); the "4"/Z mark near **G**; the lens hook beside **α** (**♄ Saturn** vs. a script terminal of **ϱ/α**); and the V/v mark by **C**. The symbol for **Saturn** (**♄**) appears along the rays marking the tested distances. [These small glyphs are at the print/ink limit, not the scan limit.]

[The upper-right cluster of this figure carries more than two labels I cannot resolve with confidence (the small Greek minuscules and planetary symbols along the dotted arcs)]

In this figure **B C D E** represents the meridian, to be conceived as lying just beneath the outermost eighth sphere, whose center is **A** — the same as the center of the universe and of the Earth, which is to be understood within its own compass as passing through **N O P Q**. From the circumference of the outermost circle, draw orthogonal lines through the center: let these be **B A D**, expressing the vertical, and **E A C**, expressing the horizon. Within the meridian of the eighth sphere let another circle be drawn, lying in the same plane, **F I K L**, which is understood as described at some distance from the Earth, according to the presupposed —

— position assumed for the star's distance from the Earth: whether its nearest distance, at the Moon; its most remote, at the Sun; or even its farthest elongation, at Saturn. For it is at these three places that I propose to make the test of the incident parallax [diversitas].

Let us therefore first assume that orb taken for the lunar concavity nearest the Earth, which Copernicus [Copernicus] showed to be not less than 52 Earth-semidiameters — indeed, somewhat greater, by 17 sixtieths [scrupuli] of one part — although, to make the matter come out more clearly, I deliberately leave that fraction aside here. Now let this star, crossing the meridian in that orb, be carried

(as to its higher position) near **G**, and (as to its lower position) close to **H**. Through these two points let lines be drawn, intersecting both at the Earth's uppermost surface **N** and at its center **A**, and then continuing outward as far as the eighth sphere; let these be **N G β** and **A G γ** for the higher position, and **N H δ** and **A H Z** with respect to the lower. The quadrant **B C**, moreover, denotes that northern portion of the meridian intercepted between the zenith of the head [Zenith Caputum] and the horizon; in it let **α** be the Pole of the World [Polus Mundi], about which all the stars revolve at equal distances by the motion of the whole, and the Pole Star [Polaris Stella] nearest to it, describing the smallest circle, is marked by **ϑ γ**. Any other star, however, that holds the meridian at almost the same moment as the New Star, is understood to mark out near the Pole the circle **S T V X** — as, for instance, the head of Cassiopeia [Caput Cassiopeae], or even Schedir [Schedir]. The New Star itself, then, is to be conceived as revolved into **η Y Z**, on the supposition that in the eighth sphere it is carried around the Pole equally on every side, after the manner of the other stars, and therefore stands at equal distance from them both above and below — which is indeed how it actually behaved. Supposing, nonetheless, that it lay at **G** and **H**, distant from the center by at least the magnitude **A G** and **A H** of 52 semi —

— diameters of the Earth, just beneath the Moon's concave orb: I say that it will by no means represent the same circle, but will, on both sides, yield perceptibly different distances from the stars that cross the meridian together with it — the difference being quite plainly perceptible, as will now be shown.

First, in the triangle **M N A**, which is by construction right-angled — namely with the line **H N** produced as far as **M**, until another line drawn from the center **A** meets it orthogonally at **M** (for otherwise the angle at **H** would not readily be commensurable, since the triangle **A N H** does not by itself afford sufficient data) — since, then, in this small triangle the angle **M N A** exhibits the complement of the star's altitude at its nearest meridian transit, and since its elevation above the horizon, as observed at Herrevad [Herritzwadium] at the place of our observation, was found to be 27 degrees, 1 minute, 45 seconds, that complement, or angle **M N A**, will be 62 degrees, 1 minute, 15 seconds — being equal to its opposite **F N H**. The side **N A**, the semidiameter of the Earth, is here taken to be of 10,000,000 particles, so that by a larger distribution of the numbers the inquiry into the matter may come out precise; and by the operation of plane triangles the side **M A** comes to 8,849,876 of the same particles.

Next, in the triangle **M H A**, right-angled by the construction just laid down, where the side **H A** is taken as 52 semidiameters from the center of the Earth to

the lowest point of the Moon — or 52,000,000 of like particles — then, since in the right triangle two sides are now established, the angle at **H** cannot remain unknown: it is 0 degrees, 1 minute, 58 seconds, 31 thirds.

By the same reasoning, considering here, for the supreme altitude near **G**, the triangle **N G A** — which, as before, for the convenience of the operation we recast into a right triangle by producing the line **G N** to **R**, until the perpendicular **A R** drops to meet it from **A** — :

In the triangle **A R N**, then, which is right-angled, since the angle **R N A** is given from the complement of the maximum altitude as 5 degrees, 50 minutes (for it is fitting, if the star's minimum altitude was $27\frac{3}{4}$ degrees, that its highest should come out $84\frac{1}{6}$ degrees, with the Pole standing at the intermediate place of 55 degrees, 1 minute, 58 seconds) — and since it makes no difference whether we use the true or the apparent altitudes here (if any difference were to intervene), for the result comes to the same, seeing that the discrimination of the parallax, which we aim to investigate, is, in one degree or another, very slight; we, however, here use the true altitudes, on the ground that they introduce no difference, whether with respect to the surface of the Earth or to its center, in the eighth sphere. Since, then, in the same right triangle the side **N A** is, as before, 10,000,000, the perpendicular **R A** comes out 1,016,351; and therefore, in the triangle **R G A**, from the side **G A** equal to **A H** given before (since both are radii of the same circle), with **R A** just now found, and the angle at **R** being right, the angle **R G A** will result — measuring the parallax of the supreme altitude — as 6 minutes, 43 seconds.

Therefore, when these two parallaxes, found by this reasoning for both the nearest and the greatest altitude, are compared with each other, it will be plain that in its higher position the New Star is seen from **N** through **G** at β , whereas a line drawn from the center of the Earth **A** through **G** in fact falls at γ . By the magnitude, then, of the angle $\eta G \beta$, equal to the angle **N G A**, the parallax of the supreme altitude, that star was distant from **S** — whether the head of Cassiopeia [Caput Cassiopeae] or the brighter of Cathedra [Cathedra Lucidior] be understood there — and by just as much —

the star, lying just as much nearer to the Pole Star and also to one situated close to the meridian.

By contrast, when the star stands in the more sloping position relative to the meridian — existing at **H**, it will be seen near δ , since from **A**, the center of the Earth, it would likewise lie near **z**. And so the divergence by which it is there

displaced from the stars is measured by the angle $ZH\delta$, equal to NHA , which the parallax first sought out measured at $1^{\circ}58'31''$.

This much, therefore, the star now approaches more nearly to the Head, or to the Chair of Cassiopeia [Cathedra Cassiopeae], when it lies close to V below this point, than it diverged from it before — when it was set in its highest position — for the amount of parallax which was then inferred. And so, combining the two parallaxes, both the one that occurred near the vertex, which was $0^{\circ}6'43''$, and the one toward the horizon, $1^{\circ}58'31''$, the total sum will be $2^{\circ}4'55''14'''$. By this much, very nearly, I affirm, the interval of the New Star would have shifted — the interval which it had from the Head or Chair of Cassiopeia in each of its two positions near the meridian, both above and below the Pole — if it had not stood farther from the Earth than the lowest concavity of the Lunar Sphere represented by $F\ G\ H\ I$ requires (provided only that they had occupied the meridian precisely at the same time, the difference that intervenes being treated afterward). Likewise, with respect to the Pole Star, in the higher position it would have approached more nearly, by the amount of the angle $VG\beta$; while in the lower position it would have receded farther from it by the measure of the angle $ZH\delta$.

Therefore, since here it would be carried farther off by $58'31''$, but there would draw nearer by $0^{\circ}6'43''$, there will also arise here a difference between the supreme distance, which is represented by βV , and the lowest, indicated by $Z\gamma$ — so that this too turns out to be no less than before, namely $1^{\circ}1'5\frac{1}{4}'$. And such a divergence as regards distance — in the higher and the lower placement on the meridian, and with respect to those said to lie in the Head and the Chair of Cassiopeia, and above all the Pole Star —

this star would have obtained, had it shone forth only just barely within the bounds of the Lunar Sphere. But since it has by no means displayed so great a difference of interval — indeed none at all — what was being assumed is absurd: namely, that the New Star did not pass beyond the limits of the Lunar Sphere. And therefore, that it stood in some place still nearer the Earth, below the concavity of the Moon's Sphere (as Aristotelian philosophy maintains, and no otherwise), is utterly false. Anyone who attempts to overturn this Demonstration must prove that the Observer was thoroughly blind and the Instrument worthless.

But how could it have happened that an error of more than a whole degree should occur, whether through the fault of the Observer or of the Instrument — especially given the diligence and the precautions that were employed, of which I have spoken before? Indeed, even by sheer inspection, without any Instrument at

all, it could be discerned that this star admitted no such parallax — and this by a comparison made with the middle small star of the Chair, the eleventh in number, which is near it and was not far removed from the meridian, the New Star being situated at the same place. For since this star in fact stood apart from the New Star in every position by a degree and a half — in the upper place by one degree and very nearly two thirds; in the lower, by not quite a whole degree — so that it would have departed by more than one and a half [degrees], in the larger interval around the Vertex, than it would be when, in the more sloping position, they drew near to the horizon: to fail to discern that divergence, at so close an interval, with the eyes alone and without any other aid, would be to be blind rather than to see.

By no means, then, can it be admitted that this star stood just barely within the bounds of the Lunar Revolutions, and far less in any place still nearer the Earth. For then a still greater...

angle of divergence would have arisen, and the matter would have been carried off into something still more monstrously absurd. This is what we set out to demonstrate by this first line of argument.

It must be noted, however, that if we suppose the lowest concavity of the Lunar Sphere to be removed at least 33 Earth-semidiameters from the Earth — following the doctrine of Ptolemy and the Ancients — then everything preceding that we demonstrated concerning the parallaxes would turn out much larger and more evident. But since Observation itself has taught us that the Copernican Hypotheses for the Moon present its distances as the closest to the truth, I was unwilling to accept false and incongruous values, however much that divergence — by which I wished to prove the proposed matter — would have come out larger in this latter way. For even by abiding by the truth of the matter, it is sufficiently evident.

Now, raising our star higher, up to the convexity of the Solar Sphere — whether even there, or in the space intercepted between this and the boundaries of the Moon (which, as was just said, exceeds the distance from the Earth to the Moon about twenty times over) — it may safely find a place: this we shall put to the test.

Employing, therefore, the preceding Figuration, and first in the lower Altitude, the angle MNA remaining as before, $62^{\circ}0'15''$, with $NA = 10,000,000$ and $MA = 8,849,876$, and all the rest proceeding by the same course of Demonstration as before, with only this side HA changed to the magnitude of the supreme distance of the Sun from the Earth — when it is at apogee — which according to our own

reckonings is defined in Chapter I [Cap. I] as 1,182 Earth-semidiameters (exceeding the Copernican value because of the greater Eccentricity than he supposed, by a third part): there arises accordingly now the angle MHA, measuring the parallax in the more sloping position, at $0^{\circ}2'34''$.

But in the supreme placement toward the Zenith, the angle RGA comes out, according to the same reasonings as those used before...

and assuming GA now equal to the most remote Solar distance, $0^{\circ}0'18''$, which — if we add to it, for the same reasons we had to do in the case of the Moon, the figures as before — there emerges as the difference of remoteness of the New Star from the aforesaid stars as they cross the meridian with it, $0^{\circ}2'52''$. Yet although this difference is not very great, since nevertheless it nearly reaches three full minutes, and the Instrument we used displayed even single minutes distinctly one by one, this discrepancy was by no means imperceptible.

From this, therefore — since not even at the supreme Solar distance and elevation has this star excluded every indication of Parallax, but it would have varied its supreme and nearest distances by three minutes, which however the accurate Observation itself did not allow, exhibiting them rather at precisely the same point of a scruple, and with the angle of the Instrument in no way varying but showing the same value — for this reason here too it is clear that this New Star must be set still higher away from the Earth than the apex of the Solar Revolutions reaches, and consequently that it will hold a place far less within the space intercepted between the two Luminaries. This we have striven to conclude demonstratively, in just the same way as before.

Indeed, we shall make the attempt — ascending even beyond the most remote Revolutions of Saturn — to see whether there is any divergence at all, and how slight the suggestion of it may be. For although, owing to Saturn's very great distance from the Earth, the Parallaxes there come out almost insensible (the Earth's semidiameter holding a scarcely perceptible proportion to so immense a distance), nevertheless that divergence, however slight, cannot possibly be altogether nothing. And so we shall not leave this case unexplored either.

It also follows from the demonstrations set out by Copernicus [Copernicus] in Book V, Chapter IX, that Saturn's apogee is removed by 9 degrees 42 minutes [part. 9. minut. 42] of the kind of which the semidiameter of the Sun's orbit [Orbis Solis] is one. Now since half the annual orbit [Orbis annui semissis], measured by the same standard, amounts to 1,142 semidiameters of the Earth, Saturn at its farthest will be distant 11,077 Earth-semidiameters from the Sun; and adding to

this the gap from the Sun to us (of which I have spoken), the interval comes out to about 12,220 — as I shall set forth more readily and more fully in the following chapter when applying these matters to our own hypotheses [Hypothesibus]. But let us assume still a little more, so that this New Star [Stella haec Nova] may be understood to be set 12,300 Earth-semidiameters away, somewhat exceeding even Saturn's own vast revolutions.

With all the other terms kept as before in the same figure (except that the latitude [Latitudo] is now taken to be H, on the supposition of 12,300 Earth-semidiameters), we shall find — for the star remaining at its lowest altitude — that the parallactic angle works out to $MHA = 0^\circ 0' 14''$ [Angulum Parallaxeos $MHA /. 0. // . 14$]. At its greatest elevation, however, the same angle of diversity will be about $0^\circ 0' 2''$ [/. 0. // . 2 ferè]. Therefore, combining the two parallaxes for the reasons set out earlier, the difference of distance will come out a little above Saturn's sphere, $0' 16''$ [//. 16] — to the extent that the star's interval ought to vary at the lower and at the highest altitude. This little difference is indeed extremely small, exceeding by a trifle a quarter part of one minute, and therefore scarcely discernible by instrument. And yet, when the instrument's angle, kept utterly unchanged from the lowest to the highest position through repeated observations (as I have several times said), gave no hint at all — not even the slightest trace — of any difference, but in both positions bisected the stars to be measured exactly through their centers, with no part of any of them standing out more or less here than there:

— this surely was bound to happen, given so tiny a difference. For a quarter part of one minute, even when the largest portion of the Nova was being viewed, did not occupy even of a keen observer's eye a part wholly imperceptible.

It is therefore more fitting, and more probable, that — granted we rely here on such slender indications [Tecmiriis] — the star itself transcended Saturn's sphere, however far off, and by no means held its seat within this sphere and the Sun's orbit, still less in that space which lies from the Sun down to the Moon; and least of all of any place below this, in the elementary region of the world. These three points, by the aforesaid inferences, I have aimed to confirm from sound geometric observations.

We conclude, accordingly, that since the star could obtain no place either in the elementary world below the Moon, nor from there up to the Sun, nor indeed even from there up to Saturn's loftiest summit — a claim that, weighed by geometric observation, cannot be overthrown — it necessarily follows that the star, in the outermost Eighth Sphere [Octava Sphaera] of all, has claimed for itself a seat

among the rest of the fixed stars [Affixas Stellas], above the revolutions of the secondary movables. This is what I have undertaken to make plain and to demonstrate by this second proof [secunda comprobatione].

But lest some quibbler should raise the objection that the stars I have chiefly assumed did not cross the meridian precisely together with this Nova, and should presume on that score to seek some support for attacking our assertion — although among the discerning this carries no weight in itself, since whether the stars crossed the meridian exactly at the same moment as the star, or only nearly so, the quantities shown by our reasoning from the distances could vary only very slightly — lest, I say, anyone, looking too hard for a knot in a bulrush [in scirpo nodum quaerens], should here

suspect that any obstacle lies hidden, I shall point out what positions the illustrious stars of Cassiopeia [Cassiopea] ought to have had — stars which crossed the meridian near the Nova, at this distance from it, both toward the zenith and toward the horizon. In both cases that star was set exactly on the meridian, while the others were in their own arrangements on this side or that, according as their positions carried them. These positions are so ordered that, if this Nova had blazed out next to the lunar or even the solar sphere (for just above Saturn these matters are too minute), the difference from the observed distances — which in both cases were exactly the same with respect to each individual star — would be in plain view.

It will be very easy to examine this and to reduce it to numbers, provided we everywhere employ the right ascension [Ascensionem Rectam] of the New Star that we have determined. For since that star stands on the meridian, on the principal vertical circle, whatever the parallax may be it remains one and the same, the declination [Declinatione] alone being altered — in proportion to the amount of parallax — both in the higher and in the lower position. Then at last, comparing these with the right ascensions and declinations of the stars (so that a triangle is formed, having two sides together with the included angle known, and hence — not to keep it hidden — exhibiting the third side, the distance), we shall track down the distance we seek.

So that everything may be conceived more correctly, and demonstrated beyond doubt, we shall make use of the following diagram [Schematismo], which will represent the arrangement of the stars both above and below the pole, with respect to the position of the Nova, so far as it can be done, so that they may to some extent be distinguished from one another.

Diagram. A large circle represents the celestial sphere. Across it run a meridian, an equator, and several dotted arcs descending from points near the top toward the lower right, mapping the positions of Cassiopeia's stars and the New Star both above and below the pole. A small circle near the upper right (around A) marks the polar region/pole; star symbols (asterisks) mark the stellar positions. The explanatory text printed beneath the figure keys the labels:

- A (upper right, small circle): the north pole of the equator [Polus Boreus]
- B (top): the New Star on the meridian, above the pole
- C (right): the New Star, below the pole
- D, E (upper right, near A): the Pole Star [Polaris Stella] in its two positions
- F, G: the eleventh star of Cassiopeia [Undecima Cassiopeae], near which the Nova lay (G is inked on the figure; F is cited in the printed key "ad F & G" but no "F" mark could be located on the figure — likely faint/abraded near B [F not located])
- H, I: the Bend [Flexura], near H and I
- K, L: the Bright Star of the Chair [Lucida Cathedra], in its two positions
- M, N: the Girdle [Cingulum]
- λ B μ ν (across the top, through B): the Meridian
- τ ζ γ χ : the Equator [Aequator]
- T, S (left): endpoints of an arc; V, X, Y, Z and zodiacal/Greek lettering trace graduated arcs along the lower left
- O (upper left), P (lower right, below N): further star positions — not keyed in the printed text below the figure
- The lower-right radial line is graduated, reading from the inner equator/meridian crossing outward toward the rim: Y · 3 · ε · d · ϑ · 2, with a zodiac glyph at the equator edge at the right. The only Arabic numerals inked on this radius are 3 and 2 (no legible "1"; no running "1, 2, 3..." sequence). The "d"-like mark between ε and ϑ may instead be a Leo glyph [ϱ ?], the equator-edge zodiac glyph reads as an Aries-like form but does not resolve cleanly [?], and a "♌/♍"-like glyph at the right end of the upper-left star row near O/Q does not resolve [?]

Let it be understood, then, that λ B μ ν is the Meridian; τ ζ γ χ the Equator, whose north pole is at A. Let the New Star be on the meridian above the pole at B, and below it at C. The Pole Star [Polaris Stella] is then understood, in each of its two positions, to be near D and E.

The eleventh star of Cassiopeia [Undecima Cassiopeae], near which the Nova lay, is at F and G.

The Bend [Flexura] is near H and I.

The Bright Star of the Chair [Lucida Cathedra], in each of its two positions, is at K and L.

The Girdle [Cingulum] is at M and N. The Breast, or Schedir, lies near O above; toward P, lower down. Let the star in the Head be Q, above the pole, and R below it. All of this is sufficiently clear from the figure itself.

From these distances of the Nova, both above and below the pole — on the supposition of an elongation from the Earth as great as would be the case for the orbs of the Moon or the Sun, that is, if the star had not stood at a greater remove from us — we shall investigate the matter as follows.

Now the true right ascension that the Nova actually had was determined precisely in Chapter Five [Capite quinto] as $0^{\circ} 26' 25''$ [p. 0. /. 26. //. 25]. Since, as we said, this remains everywhere the same upon the meridian, both above and below the pole — there being no difference at all between the true and the apparent ascension, however great the parallax in some vertical circle may finally turn out to be — the true declination was found, in addition, to be $61^{\circ} 46' 45''$ [part. 61. /. 46. //. 45]. [Margin: Meridiano] This declination undergoes a change proportional to the assumed distance of the star from the Earth, as great as the parallax in the highest or lowest position on the meridian requires.

First, then, at a distance from the Earth of 52 semidiameters, near the bounds of the Moon — since the parallax was found at its minimum altitude, on the horizon of our observation, to be $0^{\circ} 58' 31''$ [/. 58. //. 31] — when this is subtracted from the true declination, it leaves the apparent declination as $60^{\circ} 48' 14''$ [p. 60. /. 48. //. 14]. But at the highest position on the meridian the difference of aspect [Aspectus diversitas] was $0^{\circ} 6' 43''$ [/. 6. //. 43], which, added to the true declination of the Nova, gives the declination as it appears from the surface of the Earth: $61^{\circ} 53' 28''$ [part. 61. /. 53. //. 28].

Proceeding in just the same way for the bounds of the Sun's orb, the apparent declination near the lowest altitude comes out as $61^{\circ} 44' 11''$ [p. 61. /. 44. //. 11], and at the highest as $61^{\circ} 47' 3''$ [p. 61. /. 47. //. 3].

With these laid down as our foundation, we shall construct the intervals between the stars, according to their right ascensions and declinations as faithfully recorded from our observations at the beginning of Chapter Five [Capitis Quinti]

— which, however, will here be repeated as the work requires — in the following order.

I.

To investigate, from the distance of the New Star to the Pole Star in both positions — both below and above the pole — whether this star stood farther from the Earth than the Moon or the Sun.

The right ascension of the Pole Star, according to our verification at that time, is $5^{\circ} 3\frac{1}{2}'$ [part. 5. /. $3\frac{1}{2}'$]; its declination is $86^{\circ} 59' 34''$ [part. 86. /. 59. //. 34]. Therefore, when the right ascension of the Pole Star is subtracted, the angles CAE and BAD are given, both above and below the pole, as $4^{\circ} 37' 5''$ [part. 4. /. 37. //. 5], and the sides EA and DA — the complement of the Pole Star's declination — as $3^{\circ} 0' 15''$ [part. 3. /. 0. //. 15]. Accordingly, with the apparent declinations of the Nova just indicated applied — taking the lowest distance of the Moon from the Earth and the highest of the Sun — the star's distances from the Pole Star, both at its highest and at its lowest altitude, come out as follows.

Table. A bracketed table of triangle sides for two assumed distances of the star from the Earth — near the Moon (52 semidiameters) and near the Sun (1182 semidiameters). The left brace groups the lower pair under *Infra* (below the pole), the right under *Supra* (above the pole). Each value is given in degrees (P.), minutes (/), and seconds (//.).

In remotion from the Earth near:

Posit ion	Side	LUNAM (52 Semidiametr) P.	/ / . (1182) P.	/ / . Designation
Infra	Latu s CA	29	4 28 6	4 Compl. Decl. Nov. 9 [complement of declination of the Nova]
Infra	Latu s CE	26	1 25 0	1 Distantia quæsitā 3 [distance sought]
Supr a	Latu s BA	28	3 28 2	5 Compl. Decl. Novæ 7
Supr a	Latu s DB	25	5 25 6	2 Distantia quæsitā 1

II.

To investigate the same thing from the little star in the Seat of Cassiopeia, which was near the Nova.

The right ascension of this eleventh star is $2^{\circ} 20\frac{2}{3}'$ [part. 2. min. $20\frac{2}{3}$]. If the right ascension of the Nova, indicated earlier, is subtracted from it, there arises the angle GAC below the pole, and the other angle FAB above, as $1^{\circ} 53' 55''$ [part. 1. /. 53. //. 55], equal on both sides. From this it is clear that this star was not far from the meridian when the Nova was crossing it, so that the difference is not quite a full two degrees. For this reason the difference between the upper and lower distance was the more readily apparent to the eye, since the Nova was very close to this eleventh star. By the complement of this little star — being $60^{\circ} 34'$ [part. 60. min. 34] — the sides GA and FA are given as $29^{\circ} 26'$ [part. 29. minut. 26].

Therefore, here too, with the right ascension of the Nova and the apparent declinations applied — which are the quantities to be sought — they will come out in this way.

Table.

In remotion from the Earth near:

Positi on	Side	LUNAM (52 Semidiametr) P.	/ / / SOLEM . . (1182) P.	/ / / . .	Designation
Infra	Latus	29	1 4 28	1 4	Compl. Decl.
	CA		1 6	5 9	Nov.
Infra	Latus	0	5 3 1	2 9	Distantia
	GC		7 6	9	quæsita
Supra	Latus	28	6 3 28	1 5	Compl. Decl.
	BA		2	2 7	Novæ
Supra	Latus	1	3 3 1	3 2	Distantia
	BF		6 3	1 2	quæsita

III.

To explore the same thing from the star that is in the Bend, near the Loins [in Flexura prope Ilia].

The right ascension of this fixed star is $7^{\circ} 56\frac{2}{3}'$ [part. 7. /. $56\frac{2}{3}$]; its declination, $58^{\circ} 24'$ [part. 58. /. 24]. Therefore the angle IAC, as well as HAB, is on both sides $7^{\circ} 29'$

55" [P. 7. /. 29. //. 55], and the side — both IA and HA — is 31° 36' [part. 31. /. 36]. The rest come out in this manner.

Table.

In remotion from the Earth near:

Positi on	Side	LUNAM (52 Semidiametr) P.	/		SOLEM (1182) P.	/		Designation
			.	.		.	.	
Infra	Latus	29	1	4	28	1	4	Compl. Decl.
	CA		1	6		5	9	Nov.
Infra	Latus	4	2	1	5	0	2	Distantia
	IC		9	7		8		quæsita
Supra	Latus	28	6	3	28	1	5	Compl. Decl.
	BA			2		2	7	Novæ
Supra	Latus	5	6	2	5	2	1	Distantia
	HB			0		7		quæsita

III.

To make the same thing clear by means of the Bright Star of the Chair [Lucida Cathedræ].

The brighter star of the Chair had a right ascension of 356° 43½' [P. 356. /. 43½] and a declination of 56° 48½' [P. 56. min. 48½], whose complement — the arc LA and KA on either side — is 33° 11½' [part. 33. /. 11½]. The angles LAC and KAB arise from the difference in ascension between the Nova and this star, being everywhere 3° 43' 5" [part. 3. /. 43. //. 5]. The remaining quantities of this kind will be as follows.

[Continuation of comparison IIII — the Bright Star of the Chair (Lucida Cathedrae). The triangle-side table for that comparison appears at the top of this page.]

In its remoteness from the Earth, near

		The Moon (52 semidiameters) —	The Sun (1182 semidiameters) —	Computed
		Side P. ' "	Side P. ' "	
Below	Side	29 11 46	28 15 49	

	Side	The Moon (52 semidiameters) — P. ' "	The Sun (1182 semidiameters) — P. ' "	
[Infra]	CA			Declination of the New Star
Below	Side	4 26 2	5 16 46	Distance sought
[Infra]	LC			
Above	Side	28 6 32	28 12 57	Computed
[Supra]	BA			Declination of the New Star
Above	Side	5 25 22	5 19 26	Distance sought
[Supra]	KB			

V.

To demonstrate the same thing from the star that lies in the Belt [of Cassiopeia].

The star that lies in the Belt, or below the Breasts of Cassiopeia — the third in number — corresponds to $5^{\circ} 58\frac{1}{2}'$ of the Equator [responds to degrees of the Equator at P. $5^{\circ} 58\frac{1}{2}'$], having a Declination of $55^{\circ} 31\frac{1}{2}'$. Therefore the angles CAN and CAM turn out to be $5^{\circ} 31' 55''$, and the sides NA and MA come to $34^{\circ} 28\frac{1}{2}'$. The rest follows as below.

In its remoteness from the Earth, near

	Side	The Moon (52 semidiameters) — P. ' "	The Sun (1182 semidiameters) — P. ' "	
Below	Side	29 11 46	28 15 49	Computed
[Infra]	CA			Declination of the New Star
Below	Side	6 1 38	6 50 28	Distance sought
[Infra]	NC			
Above	Side	28 6 32	28 12 57	Computed
[Supra]	BA			Declination of the New Star
Above	Side	6 58 43	6 53 0	Distance sought
[Supra]	BM			

VI.

To test the same thing against the star in the Breast of Cassiopeia, called Schedir in the catalogues.

Schedir appears with a Right Ascension of $4^{\circ} 12\frac{2}{3}'$ and a Declination of $54^{\circ} 11\frac{1}{2}'$. From this the angles PAC and SAO come to $3^{\circ} 46' 15''$. The side PA, together with OA, is $35^{\circ} 48\frac{1}{2}'$. The values sought come out as follows.

In its remoteness from the Earth, near

	Side	The Moon (52 semidiameters) — P. ' "	The Sun (1182 semidiameters) — P. ' "	
Below [Infra]	Side CA	29 11 46	28 15 49	Computed Declination of the New Star
Below [Infra]	Side PC	6 54 47	7 48 8	Distance sought
Above [Supra]	Side BA	28 6 32	28 12 57	Computed Declination of the New Star
Above [Supra]	Side BO	7 57 3	7 50 53	Distance sought

VII.

To test the same thing once again, from the little star in the Head of Cassiopeia.

This star's Right Ascension is $3^{\circ} 26\frac{1}{4}'$, its Declination $51^{\circ} 32\frac{1}{2}'$. From these the angles RAC and QAB come to $2^{\circ} 59' 50''$. The sides RA and QA are $38^{\circ} 27\frac{1}{2}'$. The quantities to be derived from these come out in the manner that follows.

In its remoteness from the Earth, near

	Side	The Moon (52 semidiameters) — P. ' "	The Sun (1182 semidiameters) — P. ' "	
Below [Infra]	Side CA	29 11 46	28 15 49	Computed Declination of the

		The Moon (52 semidiameters) — P. ' "	The Sun (1182 semidiameters) — P. ' "	
	Side			New Star
Below [Infra]	Side RC	9 24 32	10 19 28	Distance sought
Above [Supra]	Side BA	28 6 32	28 12 57	Computed Declination of the New Star
Above [Supra]	Side QB	10 28 35	10 22 17	Distance sought

Seven times now I have explored the distances of the New Star from certain Fixed Stars of Cassiopeia — both at the highest Meridian altitude and at the lowest — taking as my premise a twofold remoteness of the star from the Earth: namely, the nearer one, at the concave surface of the Lunar Sphere, and the farther one, at the convex surface of the Solar [sphere]. My purpose was that the divergence arising from these assumptions might be recognized more reliably, and that these premised distances from the Earth might be plainly shown to be far too close, so that either assumption is reduced to absurdity.

In investigating these distances — both for the Lunar and for the Solar remoteness — I was all the more diligent and painstaking, so as to prove the more openly that this New Star shows, in its upper and lower position, an evident discrepancy in its distance from the stars with which it passed close by the Meridian, within the assumed limits.† And [I did this] so that no one could disparage the preceding Demonstration on the grounds that the star did not occupy the Meridian precisely together with these stars. So that these very distinctions might be set before the eye more readily and more openly, I will draw up a short Table of them.

[Margin: † it had been somewhat (more obtuse?)]

TABELLA

A TABLE exhibiting the observed distances of the New Star from certain stars of Cassiopeia with which it passed closest to the Meridian, in both Positions — both below and above the Pole — on the supposition of its twofold distance from the Earth.

Names of the Fixed Stars	Moon — Below: P. ' "	Moon — Above: P. ' "	Moon — Differ.: P. ' "	Sun — Below: P. ' "	Sun — Above: P. ' "	Sun — Differ.: P. ' "
Polari [Polaris]	26 12 10	25 6 56	1 5 14	25 16 13	25 13 21	0 2 52
Vndecim a [the Eleventh]	0 57 36	1 36 33	0 38 57	1 29 9	1 31 22	0 2 13
Flexura [the Bend]	4 29 17	5 6 20	0 37 3	5 0 28	5 2 15	0 1 47
Luc. Cath. [Bright Star of the Chair]	4 26 2	5 25 22	0 59 20	5 16 46	5 19 26	0 2 40
Cingulo [the Belt]	6 1 38	6 58 43	0 57 5	6 50 28	6 53 0	0 2 32
Schedir	6 54 47	7 57 3	1 2 16	7 48 8	7 50 53	0 2 45
Capite [the Head]	9 24 32	10 28 35	1 4 3	10 19 28	10 22 17	0 2 49

From this difference in distances — the difference this Star would have exhibited at its highest and lowest Altitude relative to the stars of Cassiopeia that passed nearest the Meridian along with it — it is sufficiently clear that the star stood neither within the bounds of the Moon nor even of the Sun. For in each place it yielded, by Observation, exactly the same interval from these stars that I set out in Chapter 4, so that there was not the slightest discrepancy underlying it — a discrepancy that with respect to the Moon would in some cases have come close to a full degree, and in a few would even have exceeded it. In the case of the distance from the Eleventh and from the Bend, the difference is indeed not so great, yet it is still quite evident; and that Eleventh star, since it was so close to the New Star, could show by the unaided eye alone that the star admitted no Parallax, given that both above [the Pole] and below

than below the pole, it was seen to be removed from it [the pole] in exactly equal measure — and yet, by two-thirds of a single degree, it had been nearer to it at its lowest altitude than at its highest. This approach could quite plainly be discerned well enough by direct sight, so that I marvel that there were any mathematicians of an intellect and eyesight so dull as to attempt to make this star sublunary.

To attempt to prove this very thing at the immense distance of Saturn's revolutions is, of course, superfluous, given the exceedingly small difference of parallax that would arise there. Nevertheless, lest the star should even there have any safe refuge — supposing all the things that were observed in it with careful diligence are to be accounted for — I shall show by certain further proofs [Tecmiria] that it had none.

For whether we adopt the Ptolemaic arrangement of the celestial orbs — together with their reality according to Aristotle, a view from which Ptolemy himself, and most of the ancients, evidently did not shrink — or whether we admit, for the sake of argument, the Copernican speculation concerning the annual motion of the Earth, with the Sun at rest in the middle of the universe (leaving aside whether the orbs in this scheme are presupposed as real, or only as imaginary); or whether, finally, we follow our own distribution of the celestial Hypotheses, which abolishes the reality of the orbs and the epicycles, yet permits the Earth nonetheless to rest at the center of the universe — we shall weigh everything out. And whichever (I say) of these three assumptions we employ, this star will nowhere find a place among Saturn's highest revolutions — and therefore within the spheres or gyrations of the entire second mobile — where it could have stood motionless for a whole year and more.

For let us consider first the Ptolemaic construction of the celestial Hypotheses, which is built up out of orbs that are eccentric-and-epicyclic and,

—finally, [built up] according to the Aristotelian traditions (with which Ptolemy was imbued, so that even in the placement of comets — great astronomer though he was, and trained in Egypt under the purest air to investigate matters of this sort, though for all that he did go astray with the Greeks in this and was blind to it — he composes them out of real and solid bodies). Even if this star, set far from the zodiac, had perhaps not been subject to those epicycles, it would still necessarily have had to obey the total revolution of the orbs about the poles of the ecliptic, provided it had been fixed to any one of them; and that motion, over so great an interval of time, would have been quite evident — or rather betrayed to the naked eye. For even in the slowest sphere, that of Saturn, within a year and a third it would have completed at least 16 degrees of motion in longitude — to

say nothing of the change of latitude that would have occurred in the meantime. And as for a star advanced a little more than half a sign, who in the meantime, even glancing at it half-attentively, would not have noticed it? Indeed, within a single week it would not have been difficult to perceive this advance, since in that span it would traverse about a quarter of a degree. And although these differences of motion, in that place where the star stood, were not so very evident — because, by occupying a great latitude, it was brought very close to the pole of the ecliptic — nevertheless even there they were perceptible enough; and from the pole itself, through the star's positions, had it displayed any [difference], the corresponding discrepancies would have fallen along an arc drawn out to the ecliptic, in the very place where all the other [motions] are reckoned in terms of longitudinal motion. And yet these things could not have been otherwise. Nor would it have been possible for the star, with the stillness it preserved throughout the whole time of its duration, to keep its place anywhere else in the sphere of Saturn, unless it had been situated at the very poles of the ecliptic — from which, however, it was distant by very nearly 36 degrees.

For although the poles of Saturn's motions are not conjoined with the poles of the ecliptic, owing to a slight digression into latitude, the matter nonetheless comes round to the same result, since the difference is negligible.

It follows, therefore, that the star could not have rested within the limits of Saturn's orbs — and much less among those of the other planets, which, drawing nearer and nearer to the Earth, occupied [progressively larger] spheres. For then, being carried forward still more rapidly, it would have changed its place by far more. According to this Ptolemaic ordering of the spheres, then, and the Aristotelian solidity of those same spheres, the new star could not have remained motionless for so long a time even in the slowest and most remote sphere of Saturn, and far less did it find occasion to do so in the other, lower spheres. It remains, therefore, to raise it even above this [sphere], so that it may be sought among the fixed stars — just as I had resolved to prove from the Ptolemaic distribution of the orbs.

But suppose that, following the Copernican assumption of the Earth's annual motion, we place the star in the highest sphere of Saturn, and suppose this sphere to be solid and real (as Copernicus too, in keeping with the long-received opinion, seems to have held). Then the same thing will result as before — namely, the star carried forward, together with the deduction of its orb. Moreover, it would in addition have been subject to the Earth's annual motion, and would have undergone retrogradations and stations in their due season; for while the star

endured, the Earth in the meantime must (if it moved) have completed more than a full annual circle.

Indeed, even if the reality of the orbs were removed from the Copernican symmetry of the world, this star could in no way have come to rest in the orb of Saturn so as to cling perpetually to a single point beneath the Eighth Sphere — because of the commutation of the Earth's orb, which would necessarily have produced for it, now on this side, now on that, evident

—evident [digressions], which Copernicus calls the parallaxes of the orb. These deviations, even in Saturn — established as the body most remote from the Earth — are set at 5 degrees 55 minutes, a quantity quite perceptible. And so this star would, on either side, have departed from its own place; and even if by an interval not so very large (on account of its great latitude), still by one not much smaller on either side, it would have strayed from its predetermined place through the Earth's annual motion — so as, within the span of a single year, to have shifted its place by at least a full 10 degrees. But because, for as long as it lasted, it always stood at the same place beneath the Eighth Sphere, and deflected in no direction by even a minute, and was found to remain quiet and motionless among Saturn's revolutions according to the Copernican Hypotheses — whether the orbs be held real or not — and far less so according to the confines of the nearer planets: this is just what I had set out to infer.

There remains the proper ordering of the celestial circuits, in which I hold that the planets, in the purest aether, supported by no solid orbs, all revolve in unison about the Sun, so that they always keep it in the midst of their revolutions, as their King and Leader, regarding only the Luminaries and the highest Eighth Sphere — together with the Earth — as their center. (How this is so will be set forth more fully, with a general account, in its proper place in the following Book.) On this constitution, I say, even though this new star, in some region of the heavens no farther off than Saturn or the other upper planets are carried by their revolutions, could of itself have stood motionless and distant — being, as it were, agitated by no orbs, since their reality is not admitted there — and would not, on account of the Earth's annual rest, have felt any parallax of the center, nor again, [arising] from the semidiameter of the Earth,

a perceptible diversity of aspect [parallax]. And yet, since it is highly probable that whatever is contained beneath the Eighth Sphere [sphaera octava], within the limits of the secondary mobiles, no less than the seven Planets caught up within that vast space, is allotted some proper motion of its own by natural consent, and in no way stands fixed there motionless after the manner of the

fixed stars [Affixae Stellae] — for this reason this Star does not fall to be exempted from those laws. The same holds for Comets, which are all in truth generated within the orbital revolutions of the Planets, as will become clear from the following Books. And so these comets do not stay at rest, but all possess a certain proper motion, some swifter, some slower, and this directed toward various parts of the heavens, wherever their natural impulse carries them. And if at any time they appear to stand still, this happens incidentally: either because, with respect to our line of sight, they then ascend and descend after the manner of epicycles, as it were along a straight line — which can come about in various ways — or because, the force of their motion now failing, they gradually check their movement and at last, as it were, come to rest, just as commonly happens near the end of their disappearance, when they have already discharged their function in body, in light, and in motion alike.

Among the stars set beneath the Eighth Sphere, then — both those that are coeval with the world and endure perpetually, such as the seven we call Planets, and those that are adventitious and formed there at a certain time, even if they are dissolved a little afterward — there is implanted a certain natural power of moving, by which they mingle a proper motion of their own with the universal course. For there too rest and quiet are not fitting, as they are in the Eighth Orb.

Therefore not even according to this reckoning of ours concerning the nature and revolution of the heavenly bodies could this New Star [Stella Nova] have lingered near the bounds of Saturn, nor yet within the limits of the other Planets — which is what we set out to establish here as probable.

If, however, someone should object that there is no irrefragable necessity here — granting that he may advance something less consistent, drawn from the nature of phenomena contained within the theaters of the secondary mobiles — yet, so that this too may be met, I will add the following. Suppose the Star (of which we are treating) had remained unmoved in the same place for a whole year and a third, within the Planetary Spheres — even spheres that are not real but everywhere penetrable, utterly limpid and most fluid: even so, it could not throughout this whole span have kept an exactly identical distance from the stars of Cassiopeia, especially from those that, in their tract with respect to the Ecliptic measured from the Pole, almost coincided with it — as did, beyond the rest, the Bright One in the Chair [Lucida Cathedra], Number 12, and the one in the Foot, which is seventh in order. For meanwhile, when all the Fixed Stars had been advanced in a single common tract by one minute and nearly a sixth part of one — as is clear from what we set out in the Second Chapter [Capite Secundo]

concerning the motion of the fixed stars — it followed that the one in the foot of Cassiopeia had drawn away from this Nova by very nearly one whole minute, while the one that shines in the Chair had approached just as much nearer. Yet by the instrument the very same distance from both stars was observed precisely, both near the beginning and toward the end of the apparition. For a difference of even one whole minute was sufficiently perceptible with the instrument. As for the sixth part that remains over, we suppose — as if at least one whole minute, around that place of the heavens where the Star was lingering, had been made — the difference, with respect to the great arc, to be such, since the degrees toward the Pole come out narrower.

Therefore, since this Star throughout the whole time of its duration kept the same interval from the Fixed stars, in no way varied by a single minute, it was not standing motionless beneath them while they advanced somewhat onward; but rather, carried along necessarily together with them at an equal distance, it held a place in common with them. And for this reason it was established entirely above the Orbs of all the Planets, within the very Sphere of those same Fixed stars. Which is what we undertook to set forth and demonstrate.

And thus far, from the distances of the New Star compared with the neighboring stars of Cassiopeia, and from the other proofs joined to them, we have left it sufficiently demonstrated that it did not find a stable place either beneath the Moon in the Elementary World, nor above this as far as the Sun, nor from the Sun on up to Saturn, but that it must of necessity be placed among the outermost non-wandering [Inerrantes] stars — this we have demonstrated. Which is what we set out from the beginning to prove.

[Centered subheading, p. 443:]

To show, by the greatest and least altitudes of the Star alone, in a given altitude of the Pole, the same thing as before, without the application of any other Fixed stars.

COMPROBATIO TERTIA [Third Confirmation].

The Star itself too, by itself and without the aid of others, in its daily revolution sufficiently evidently showed that it was subject to no parallax — especially through a careful comparison of those of its altitudes that were observed on the Meridian above the Pole, and at the same Meridian below it. In both positions it was wholly equidistant from the Pole, and it exhibited the same Declination both in the greater and in the lesser situation — which could not have come about if it had been subject to any sensible parallax.

Since, however, it is not granted to adduce wholly from our own resources the Observations that confirm this very point and bear witness to it — inasmuch as, through that instrument which we were then using, the Greatest Altitude on the Meridian could not be taken — we shall here employ the Annotations of Paul Hainzel [Pauli Hainzelii], Consul of Augsburg, obtained by means of the Great Quadrant [Quadrans Maximus] we constructed there: of which, together with an explanation of the Instrument, we treated in the Fourth Chapter [Cap. Quarto]. For it will not be unfitting to turn those observations to my own uses, since I was myself the author of the Machine by which they were obtained, and since, after my departure, it was for that very reason communicated to me by Hainzel, that I might use it.

From those Observations, then, which I reviewed in the said Chapter, it is gathered that the greatest Altitude of the New Star on the Meridian was $p. 76^{\circ} 1' 34\frac{1}{2}''$ [Margin/inline: P.76.1.34½]. For when, in November, he had three times found it at an Altitude beyond those very 34 degrees, around the beginning of the following January he found it greater by one minute. We shall therefore have acted more advisedly if, in limiting these Observations, we retain the mean of them as the precise greatest Altitude — so that to the Observations made in November half a scruple [a half-minute] be added, and from that of January just as little be subtracted. For although he did not attain equally the greatest elevations in the same place, yet, since the Star, then rendered somewhat smaller, presented itself to be discerned and measured more by sighting alone, I judge that something should be granted to this Observation, single though it be: yet in such a way that, for the sake of the rest, it lose half a scruple.

The least Altitudes of this Star, observed five times by him, are noted down, and agree sufficiently among themselves, since the discrepancy of those differing most is found to be at least a third part...

of a single minute. For on 22 November and 3 January it turned out to be $20^{\circ}, 9\frac{2}{3}'$; on 27 November and 3 March, $20^{\circ}, 9\frac{1}{2}'$; and again on 12 March, $20^{\circ}, 9\frac{2}{3}'$. If, then, we take $20^{\circ}, 9\frac{1}{2}'$ here for the nearest altitude, we shall not err by anything that could fall within the range of the senses. For this is the mean among the others, which differ only slightly among themselves, and it was carefully observed twice in the same way. The greatest and least altitudes of the New Star at that horizon will therefore stand fixed and exact in the following manner.

The greatest and least meridian altitudes, carefully taken at Augsburg [Augustae Vindelicorum] by means of a very large quadrant.

	p.	'	"
Greatest altitude [Altitudo Maxima]	76	34	30
Least altitude [Altitudo Minima]	20	9	30
The difference between them [Differentia harum]	56	25	0
Half of it [Eius dimidium]	28	12	30

Half the difference, found in this way, when added to the least altitude or subtracted from the greatest, yields the elevation of the pole [Elevatio Poli] at the place of observation near Augsburg: $48^{\circ}, 22'$. This is also precisely the value most often found there from the circumpolar stars, and indeed from the Pole Star itself, using the same quadrant — just as, in the chapter mentioned earlier, I showed at great length from ten observations made with the same instrument upon various stars. For I did not repeat the very same thing so many times without purpose: much depends, in this matter, on exactly what elevation of the pole the circumpolar stars yield, so that the conclusions I am now striving to build upon them may turn out the more certain and the more evident.

For in this place, where in two or three of the stars near the pole the altitude has come out greater by half a scruple [scrupulum], this happens by reason of refraction, since those stars stand somewhat lower at their nearest altitude — just as we shall excuse this same effect, in their case too, by their proximity to the horizon. But above all the rest, the Pole Star itself bears the best and surest testimony here, since it describes the smallest circle and is subject to virtually no refraction; and besides, being in itself neither too large nor too faint, but of a middling character, it more readily allows of an accurate collimation [collimationem accuratam].

In this star, too, there is something there likewise worthy of remark: that it gives, even down to the very seconds, the same distance from the pole at that time — or, what is the same thing, the same complement of declination [Declinationis Complementum] — as our tables present for its place, verified for us from the heavens. From this it is further clear that the observations on both sides agree to the utmost exactness.

It is therefore evident that this New Star revolved about the pole in altogether the same manner as the other circumpolar bodies coeval with the world — from which it likewise marked out for itself exactly the same altitude. It follows, then, that it had very much in common with these stars, and that it was no less exempt than they from any hint of parallax. For it kept the same distance from the pole near the vertex as it did toward the horizon. When the elevation of the pole, 48° ,

22', is subtracted there from the greatest altitude of the star, which we said was 76°, 34', 30", the remainder comes out 28°, 12', 30". And likewise, subtracting from the altitude of the pole the nearest elevation of the star, 20°, 9', 30", the very same interval is obtained: 28°, 12½'. And hence on both sides there results the same declination, or distance back from the equator [ab Aequa-

-tore Remotio], this distance from the pole; and its complement, accordingly, being 61°, 47½'. This differs by the very least amount from our observation in the nearest altitude. Since, then, this star — standing so high above the pole, at an altitude of about 76½°, not even a full 14° from the zenith — obtained from the zenith the same distance it had at its nearest declivity, where it was raised not much beyond 20°, it is beyond all controversy necessary that it admitted no diversity of aspect [aspectus diversitatem] whatsoever; and therefore that it stood not within the bounds of the planets, much less below the confines of the Moon in the elemental world, but rather had fixed its seat in that most remote Eighth Sphere [Octava Sphaera] itself.

For how unevenly it would have presented its distances from the pole, above and below, had it admitted sensible parallaxes, will be made clear in the following manner, by the demonstration drawn from the diagram set out below.

Let there be set down, in the diagram next following, BCDE as the circle of the meridian, coinciding with its plane, in which let some distance be assumed from the Earth, whose center A is the same as the center of the Earth; and through KLM, as marked, let the diameters BAD and EAC be drawn crosswise, looking toward the zenith and the horizon respectively. Let the visible horizon be OKP, departing imperceptibly from the true horizon EAC in the Eighth Sphere.

Now let this New Star first be situated just below the concave of the lunar revolutions, such that the semidiameter of the larger circle is taken to be 52 semidiameters of the Earth. It is worth inquiring what parallax it would have had near Augsburg in each meridian altitude — the highest, near F, and the nearest, at G — so that the discrepancy and irregularity of its revolution about the pole may be discerned.

Diagram. A large circle representing the meridian, BCDE, with center A (the center of the Earth). A small inner circle is concentric about A, representing the Earth's globe. The vertical diameter runs from B (top) through K and A down to D (bottom); the horizontal diameter runs from E (left) through N, A, L to C (right). A second, slightly higher horizontal line OKP (the visible horizon) runs from O (left) through K to P (right), passing just above A. The point F sits at the top, just to the

right of B, with lines drawn from F down to K and to A. The point G sits on the right of the great circle, above the horizontal, with lines drawn from G to K and to A. Within the small inner circle are the points H, I (near the center, between K and A), N (left on the horizontal) and M (at the bottom of the inner circle). The construction shows the star at its highest position (near F) and its nearest position (G), with sight-lines from both the Earth's center A and the surface point K, to exhibit the parallactic displacement.

- B (top of great circle): upper end of the vertical diameter (toward zenith)
- D (bottom of great circle): lower end of the vertical diameter
- E (left of great circle): left end of the true horizon diameter
- C (right of great circle): right end of the true horizon diameter
- O (left, slightly above E): left end of the visible horizon
- P (right, slightly above C): right end of the visible horizon
- A (center): center of the Earth and of the great circle
- K (just above A): the surface point of observation (intersection of the vertical with the visible horizon OKP)
- F (top, right of B): the star at its highest meridian altitude
- G (upper right): the star at its nearest (least) meridian altitude
- H (inside the small circle, upper left of center): construction point
- I (inside the small circle, below H, near center): construction point
- N (left of A on the horizontal, on the small circle): construction point
- L (right of A on the horizontal): construction point
- M (bottom of the small circle): lower point of the Earth's globe

First, then, in the highest elevation, which was $76^{\circ}, 34\frac{1}{2}'$. Considering the triangle FKA — which we have made right-angled by adding KIA — the first angle in this little triangle IKA will be equal to the complement of the altitude, namely $13^{\circ}, 25\frac{1}{2}'$ [as angle BKF]; and with the side KA given in semidiameters of the Earth, the side IA will be 23 23138 [?]. And since FA is 52 semidiameters of the Earth, the angle IFA — that is, KFA — measuring the parallax in the highest altitude, will come out as $0^{\circ}, 15', 21''$.

Now we shall examine the nearest altitude, where in the triangle GKA — likewise made right-angled by the addition of KHA —

with this done, the angle HKA is $69^{\circ} 50\frac{1}{2}'$, that is, equal to the complement of the minimum altitude. The side HA is therefore 9,387,438 in the units where the

radius KA of the Earth is 10,000,000. Hence, since here the side AG is 52 Earth-radii, the angle of the nearest parallax KGA will be $1^{\circ} 2' 4''$.

From all this it is clear that this star, at least at its highest altitude, would, by reason of the diversity of aspect [parallax], have been brought a quarter of a degree closer to the pole; whereas at the lower elevation it would have been carried somewhat more than a full degree away from that same pole. The difference between the two intervals would thus amount to about $1^{\circ} 17\frac{1}{2}'$. This could certainly have been detected even with some quite modest instrument, let alone with a quadrant of such vast size, which subdivided each individual first minute into several parts.

If, therefore, this New Star had stood just within the nearest concavity of the orb of the Moon, it would by no means have yielded the same elevation of the pole that the fixed stars supplied, since a very conspicuous discrepancy would have come between them. For it would then have shown a maximum altitude of $76^{\circ} 19'$ and a minimum of very nearly $19^{\circ} 7'$. The difference between these is $57^{\circ} 12'$. Half of that, $28^{\circ} 36'$, added to the minimum observed altitude, would yield an elevation of the pole of $47^{\circ} 43'$ — falling short of the true elevation, repeatedly determined from the circumpolar stars, by about $39'$, that is, by two-thirds of a single degree. To suppose that this could not have been discerned by the instrument would have been quite absurd, since not even a single minute escaped notice in this work.

In no way, then, did this star find its place just below the lunar revolutions, much less in some region still

closer to the Earth — for in that case the absurdity would have been even greater. This we have undertaken to show, in the first instance, from the meridian altitudes of the star alone.

It is no different if we turn to the maximum remoteness of the Sun from the Earth, which we set at 1,182 terrestrial radii, and suppose the circle BCDE now removed to that same great distance. The parallax angle at the highest altitude, KFA, would have come out to $0^{\circ} 0' 41''$; while at the lower position, near G, it would be $0^{\circ} 2' 43''$, so that the discrepancy in the star's distance from the pole, between the high and low meridian positions, would amount to $0^{\circ} 3' 24''$. Had it occupied the convexity of the solar orb, this difference — though not in itself so very great — would still have been quite perceptible with so enormous a quadrant; and the elevation of the pole would now have come out at $48^{\circ} 20'$, less by two scruples [minutes] than the true altitude found from the stars revolving

about that same point. Nor could this have escaped detection through that quadrant, given the careful sighting carried out with it.

It follows, then, that this star could not have stood firm even at the very highest elongation of the Sun in such a way as to revolve about the pole everywhere at an equal distance, and to display the same height above it as the circumpolar fixed stars do. Far less, therefore, could it have stood in the space enclosed between the Sun and the Moon, when, as it came still closer to us, an even greater diversity [of aspect] would creep in.

As for the outermost convexity of Saturn — even though here the experiment comes down to a minimal and almost imperceptible difference, scarcely reaching a third part of a single minute — nevertheless even so tiny a quantity was in a manner detectable by that greatest instrument, provided every refinement that could be achieved in observing were applied. But since this is sufficiently evident — from indication, with the further testimonies adduced here and elsewhere (of which we have spoken before), this New Star could not have held a quiet seat even at the highest confines of Saturn, and still less within the spheres of the remaining two planets, these being for the most part intercepted by it and by the Sun.

Therefore, since this star could have held a secure place neither in the space from the Moon to the Earth, nor from the Moon up to the Sun, nor even from the Sun up to the uppermost reaches of Saturn, it necessarily follows that it stood, unmoving, alongside the most lofty luminaries of the Eighth Sphere. This we determined to prove, by this third demonstration, from the fact that in its revolutions about the pole it kept company with no other stars from the beginning, but only with these.

To infer once more, from certain observations made at different horizons and received from various other observers, the very same conclusion as before.

COMPROBATIO IIII.

In what has gone before, we carried through to the end we intended those matters that could be resolved, from certain observations we ourselves had made at some single horizon, concerning parallax and the determination of the star's distance from the Earth. It remains for us to take into our deliberation, weighing them on an equal balance, the observations made at different horizons by

different observers as well, and to inquire whether they agree with the foregoing or not. Yet, to say what is the case, those experiments are by far safer and more reliable than are carried out by some single observer at one and the same horizon, with one and the same carefully wrought instrument — provided the individual operations are performed correctly and are not subject to any appreciable fault — than if from different

horizons and by different sighters the clarification of the matter is sought. For the variety of instruments, and the diligence and circumspection of the observers — not everywhere the same in carrying out the task — can introduce some deviation from the intended aim. And as far as the subtle investigation of parallax is concerned, the error may be considerable, whether in excess or in defect. Nevertheless, since it is both elegant and in a certain way profitable — and also, in itself, the more readily wins credence with others — if the observations of different men, made in several places, are compared with one another, and from these too the knot of the matter at hand is untied, we shall bring forward certain observations made at some interval of horizons. And lest, from any subtly conducted want of diligence in the matter, some suspicion might be stirred, we shall first weigh against our own those observations made at Augsburg [Augusta Vindelicorum] with that greatest quadrant, which we know to be free of any appreciable fault. Then, so that the interval of horizons may be greater, and the discrimination among the altitudes of the stars (which we intend to derive from this) more evident, we shall also compare with our own the observations made by Muñoz [Munosius] in Spain.

Accordingly, in the figure that follows next, let I and H be the two maximum altitudes, the one accepted at Augsburg and the one here; G and F, in each case, the minima. The angles converging from the surface and the center of the Earth to these four points will measure the parallaxes at whatever distance from the Earth is presupposed — as is sufficiently clear from the preceding.

Supposing, then, that this star was removed at least as far as the elongation of the lunar concavity, it will be necessary that, at the maximum altitude at Augsburg, near H

Diagram. A large circle representing the celestial sphere (the firmament), drawn around a small inner circle (the Earth) centered on the observer's location. The horizontal diameter E–C runs through the figure as the horizon, and the vertical diameter B–D runs through it as the meridian. Several straight lines radiate from points on the small inner circle out to lettered points on the large circle, representing the lines of sight to the New Star from observers at different

positions and the apparent star-positions they yield. The construction illustrates the cross-observer comparison of the star's altitudes and the (absent) parallactic displacement.

- B (top of the large circle, on the meridian): label B
- I (top, just right of B): label I
- H (top, right of I): label H
- G (upper right of the large circle): label G
- F (right, below G, near the horizon level): label F
- E (left end of the horizontal diameter / horizon): label E
- C (right end of the horizontal diameter / horizon): label C
- D (bottom of the large circle, on the meridian): label D
- K (on the small inner circle, upper part): label K
- N (on the small inner circle, left of center): label N
- A (center of the small inner circle, the observer / Earth's center): label A
- L (on the small inner circle, right of center): label L
- M (bottom of the small inner circle): label M

taken with respect to H, [the star] is found to be $76^{\circ} 34\frac{1}{2}'$. This makes the angle of parallax $K H A$ equal to $15' 21''$ [angle $K H A = 15' 21''$]. But here in Denmark, where our own observation was being made at an altitude of nearly 84° , the angle $K I A$ comes out to $6' 43''$, measuring the parallax at the highest altitude. The difference between the two is therefore about $9'$. And by just that much would the star have appeared closer to the pole here, near its greatest altitude, than at Augsburg [Augusta Vindelicorum], had it stood near the boundaries of the lunar sphere. Yet observation in no way detected this. For the declination at Augsburg, both at its greatest and at its least altitude,

was $61^{\circ} 47\frac{1}{2}'$, and accordingly its distance from the pole was $28^{\circ} 12\frac{1}{2}'$, as we indicated earlier. Here, although the defect of the instrument made it impossible to measure the star's greatest altitude, nevertheless the same result will become clear in the following way from its distance from the Pole Star, which had also been carefully determined near the greatest altitude.

In the triangle drawn alongside, let A be the pole, B the Pole Star, and C the New Star. Now since (by the known declination of the Pole Star, $86^{\circ} 59' 45''$, according to our restitution) the side B A is given as $3^{\circ} 0' 15''$ — entirely consistent with Hainzel's observation of the distance of the Cynosure [the Pole Star] from the pole, investigated in the same year — and since the side B C, the interval between the Pole Star and the New Star, which we found to be $25^{\circ} 1' 14''$ [P. 25 1' 14"]; and

the angle B A C is given from the difference in right ascension between the Pole Star, $5^{\circ} 3' 25''$, and the New Star, $0^{\circ} 26' 25''$, so that this angle at A is $4^{\circ} 37'$ — therefore the side A C will not stay hidden: it gives the distance of the New Star from the pole as $28^{\circ} 13\frac{1}{2}'$. And in this way we have ascertained the remoteness of the New Star from the pole at its highest altitude precisely as we intended, even though it was not possible to observe it there directly. If this is compared with the value obtained at Augsburg in the highest position, of which we have just spoken, it yields a discrepancy of at most $1'$, which here merits no mention. For it ought to have been about $9'$ if this star had stood in the nearest concavity of the lunar orb.

Diagram. A narrow triangle set in the left margin alongside the text. Its apex is A (the pole) at the top; B (the Pole Star) is at the lower left; and C (the New Star) is at the bottom. The long curved/straight sides represent the sides B A and A C, with B C as the base joining the two stars.

- A (top apex): the pole
- B (lower left): the Pole Star [Stella Polaris]
- C (bottom): the New Star [Nova]

Thus, at the lowest altitude of the star at Augsburg, near G, the parallax comes out as $1^{\circ} 2' 4''$, while at Herrevad [Herritzwadium] in Scania

it comes out as at most $0^{\circ} 58\frac{1}{2}'$ near F, the difference being $1^{\circ} 3\frac{1}{2}'$ [$1' 3\frac{1}{2}''$] — by which margin the interval of the star from the pole at its nearest altitude ought to have been greater here than there, if [the star lay near the moon]. Yet through observation a discrepancy of scarcely half a minute was found, which readily merits its own excuse, since in itself it is hardly perceptible.

From all this it follows that the difference of horizon between Augsburg and this place produced no perceptible difference in the star's distance from the pole or in its declination. And therefore this star lay far above the Moon, where some portion of the Earth's circumference — indeed its whole semidiameter — bears no proportion that the senses can detect.

If we examine the same matter in the solar sphere [Sphaera Solaris], the divergence will be exceedingly slight: near the highest altitudes it scarcely reaches two-fifths of one minute, and near the nearest altitudes plainly not a sixth part of one minute. Therefore, since for the purpose of this reasoning these tiny differences are imperceptible — and far smaller still near the outermost limits of Saturn — we deliberately pass them over.

But so that the interval of horizon may be somewhat greater, and the parallactic difference correspondingly more evident, we will also bring in the observations of the most learned mathematician in Spain, Hieronymus Munosius [Jerónimo Muñoz], for the star's greatest and nearest altitude. By comparing these with our own, what we intend will be more fully proved.

He states that this star had a greatest altitude of $67^{\circ} 30'$ at Valencia in Spain, where he held the office of professor of mathematics. Accordingly, in the figure set out above, at the point H, the angle

the angle K H A came out as $1^{\circ} 25' 18''$. But here in Denmark, at point I, the angle K I A was $6' 43''$, as has been said. There thus arises a difference of parallaxes in the highest position, between Valencia and here, of $1^{\circ} 18\frac{1}{2}'$ — by just that much would the star there, on the meridian above the pole, have appeared to approach more closely to it than here, had the lunar convexity surrounded it. Yet experience showed nothing of the sort.

For although it is not permissible to settle the matter too scrupulously by means of Munosius's altitudes and distances from the pole — because he investigated these in too coarse a manner, so that as regards a sixth part of a degree or thereabouts he does not seem at all careful — nevertheless, from the distance from Schedir in Cassiopeia [Schedir Cassiopeae], which differs from ours by at most half a scruple [half a minute], and which he observed in the loftier meridian position as $7^{\circ} 50'$, it is sufficiently clear that the difference in the star's remoteness from the pole was imperceptible both here and there. For he very nearly hit upon the same meridian distance from this very Schedir as we did. Indeed, since this fixed star [Schedir] was then higher, the New Star ought to have been driven farther from it for the observer at Valencia in Spain than here; yet the contrary occurred — if any faith, to within half a minute, is to be placed in Munosius's observations.

In just the same way, with the star approaching the horizon at Valencia near F, at an altitude of $11\frac{1}{2}^{\circ}$, as the same Munosius likewise noted, the diversity of aspect would have been represented by the angle K F A as $1^{\circ} 4' 47''$. But at our location, near G, the angle of diversity K G A comes out, as has been said several times before, as $0^{\circ} 58' 31''$. There is therefore a difference of parallaxes in that horizon and in ours, near the star's nearest altitude in both places, amounting to about $1^{\circ} 6\frac{1}{4}'$ [$1^{\circ} 6\frac{1}{4}''$]. Although this is not so very great,

large and positioned in a higher region for the star here as well as there. Nevertheless, since it amounts to a tenth part of a single degree, it was sufficiently

perceptible with the application of ordinary care and a precise instrument. By the same amount, Muñoz [Jerónimo Muñoz] at Valencia would have placed the New Star nearer to Schedir in Cassiopeia, in its position of greatest decline, than I did here. Indeed, Muñoz observed there the same distance of the star from the said star [Schedir] at its highest altitude as we did — $7^{\circ} 1' 50''$ — within half a second of arc. So that not even on this reckoning was the New Star so close to the Earth as to fall short of crossing beyond the spheres of the Moon.

Here too it must be noted that at Valencia in Spain, the New Star, by this calculation, is removed farther from Schedir in Cassiopeia than at our place of observation — by about its highest altitude, $1^{\circ} 18' 1' 35''$ [recte: $1^{\circ} 18' 35''$?] — whereas in its lower position it is removed by $1^{\circ} 6\frac{1}{4}'$. There it would have been nearer to that same star than here, such that the difference comes to almost $25'$, by which the distance of the New Star in Spain would have presented itself differently — considered in either way — than here in Denmark. But since both Muñoz there and I here found one and the same distance everywhere of the New Star from the said star, so that the discrepancy is at most half a minute — which is of no significance — it follows that this star had an imperceptible parallax. Therefore it was by no means brought so close to us as the sphere of the Moon is, beside which it would have displayed so evident a difference. For this reason it chose for itself a place in the highest aether. This is what we resolved to make plain and to prove conclusively by this fourth Confirmation.

Although these differences are not so great as to imply anything perceptible in the sphere of the Sun, and much less in that of Saturn, nevertheless that this star was not located even in these or below them is sufficiently clear from the Theorems of the preceding Confirmations,

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so that there is no need to establish the same point here as well in plain terms. And so let us now bring the Fourth Confirmation to an end, adding only this: that the difference of meridians introduced no impediment into this inference, for the reason that the star was in itself motionless and was everywhere observed near the meridian. Indeed, the meridian of Augsburg [Augsburg] is not far removed toward the west from our own; and although the meridian of Valencia [Valencia] lies very far off, it nevertheless, for the reason stated, does not disturb this matter.

Therefore, since we have now proved by four unconquerable Demonstrations [Apodixibus] that this New Star not only had no commerce whatever with the

Elementary World, but did not even take up a place within the vastest Revolutions of the seven Wandering Stars [the planets] — its complete lack of parallax bearing witness to this very point — we shall conclude that it must necessarily be raised to the highest Theatres of the Fixed Stars, where, just as they do, it too stood motionless.

It would indeed be possible to attest and demonstrate this same thing still further by means of several arguments drawn from suitable Observations — for instance, by employing different azimuths and altitudes together with the moment of time, and also by particular relations to the Fixed Stars, both within and outside the meridian in varying positions. I have, however, been unwilling to amass more methods, especially since the ones I have brought forward are the simplest, the most evident, and the least liable to error in observation. All the rest entangle the matter through many circuitous turns, and, as it were, seek a knot in a bulrush, whereas by the aforesaid procedures — far easier and more thorough — it has been granted us to reach the goal we were aiming at. And thus we would have brought this Sixth Chapter to a close, were it not that one scruple or another — neither, however, particularly difficult — still remained to be removed.

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As regards the former, it concerns the Parallaxes of the Moon: whether, namely, they are really as great as is required for the Moon to be brought toward the Earth as far as the interval we have several times assumed in the Demonstration. For even though, in Ptolemy [Ptolemy] and Copernicus [Copernicus] and the other principal Authorities of Astronomy with whom I am well versed, it is plain enough what they hand down concerning the Parallaxes of the Moon and how they discovered them — nevertheless, should anyone not much practised in their volumes, or otherwise presuming to call these things into doubt, wish to deny them (as some of them have attempted who fashioned Homocentric Spheres [Homocentricos Orbes], or who not less absurdly built up the notion that all the Planets revolve in a single Sphere at an equal distance from the Earth) — I have selected from the Observations which I made in the years immediately preceding with my own Instruments six, by which it is evidently proved that the Moon produces very nearly as great a Parallax as the Copernican reckoning carries, and that it is therefore about the same distance from the Earth.

The first three of these will be from those which I took at the Tropical Signs, when the Declination changes least; deducing everything from the Meridian Altitude at that time, because the difference between the true and the apparent place with respect to Longitude is exceedingly small. Afterwards I shall add three others

taken around the 90th degree of the Ecliptic from the East, where the true and the apparent Longitude coincide.

I.

In the year 1583, on the 12th day of October, at hour 5, minute 19 P.M., the upper limb of the Moon ☾ had its greatest Altitude on the Meridian of 13°

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38'. If from this is subtracted the Semidiameter of the Moon, which was 15', the Altitude of the Centre comes out as $13^{\circ} 23'$, from which refraction subtracts 8', so that the true Altitude, free from the impediment of refraction, is $13^{\circ} 15'$. If this is taken from the Elevation of the Equator of this place, it leaves the apparent Declination of the Moon as $20^{\circ} 50'$ very nearly. Now the Longitude of the Moon at that time was about $15\frac{2}{3}^{\circ}$ of Capricorn ♐, with a Latitude of $2^{\circ} 42'$ North; and this is in accord with my own findings. Therefore its true Declination is $19^{\circ} 57'$, which, subtracted from the apparent, shows the Parallax sought to be $0^{\circ} 54'$ — which the Copernican Canons make smaller by about one and a half scruples, a matter of little importance in this place.

II.

In the year 1587, on the 4th day of August, at hour 9, minute 0, after Midday, the Altitude of the upper Limb of the Moon ☾ was observed as $15^{\circ} 20'$; that of the lower as $14^{\circ} 46'$. The apparent Diameter of the Moon was therefore $0^{\circ} 34'$, and the Altitude of its Centre $15^{\circ} 3'$. Refraction subtracts 6', so that the corrected apparent Altitude is $14^{\circ} 57'$. This, subtracted from the Elevation of the Equator, gives the apparent observed Declination as $19^{\circ} 8'$; and because the true at that time was $18^{\circ} 5'$, this subtracted from that yields the Parallax sought as $1^{\circ} 3'$ — which the Copernican numbers make smaller by at least $1\frac{1}{2}$ scruples. Now the true Declination (of which I spoke) is known from the place of the Moon to be $7^{\circ} 30\frac{1}{2}'$, with a Latitude of $5^{\circ} 12\frac{1}{2}'$ North (according to our correction in the Latitude of the Moon), as became known through computation.

III.

On the 18th day of August of the same year, at hour 7, minute 26 A.M., the Altitude of the upper horn of the Moon ☾ on the Meridian was 52°

$0'$ minutes 0. The lower [limb] gave 51 parts, $29\frac{1}{2}$ minutes; therefore the whole diameter of the Moon was 0 parts, $30\frac{1}{2}$ minutes [P.O. /. $30\frac{1}{2}$], which agrees extremely well with the Copernican values. The altitude of the center was

therefore 51 parts, $44\frac{3}{4}$ minutes [part. 51. /. $44\frac{3}{4}$]; and if from this we subtract the elevation of the equator for this place — indicated repeatedly above — there remains the apparent declination of the Moon, 17 parts, $39\frac{1}{2}$ minutes [part. 17. /. $39\frac{1}{2}$], whereas the true declination was 18 parts, 13 minutes [P.18. /.13] (for the longitude of the Moon was around the middle of 27 degrees of Gemini [II], with a latitude of 5 parts, $14\frac{1}{2}$ minutes south [part. 5. /. $14\frac{1}{2}$ Mer.]). When the former is subtracted from the latter, the parallax of the Moon comes out as 0 parts, $33\frac{1}{3}$ minutes [P.0. /. $33\frac{1}{3}$], which exceeds the Copernican value by only $\frac{1}{2}$ minute.

These three earlier [observations] are sufficient. Now I add three others made outside the meridian, for the case in which the Moon was about 90° [in longitude] from the horizon along the ecliptic. In that situation it shows no difference between apparent and true longitude, but turns the whole [parallax] into latitude. Once the true latitude has been collated, then, the investigation of the parallax will be very easy.

III.

In the year 1586, on 23 September, at hour 3, minute 9 after midnight, when the Moon was about 90° along the ecliptic from the horizon, I carefully observed the apparent longitude of its center (which, as I said, was at the same time the true one) at 7 parts, 25 minutes of Gemini [in part. 7. /.25 II], and its apparent latitude was found at the same time to be 4 parts, $39\frac{1}{2}$ minutes south [P.4. /. $39\frac{1}{2}$ Merid.]. But the true latitude, according to our reckoning, was 4 parts, 1 minute [part. 4. minut. 1]. When this is subtracted from the apparent latitude, it leaves the parallax sought, with very little trouble, at 0 parts, $38\frac{1}{2}$ minutes [part. 0. /. $38\frac{1}{2}$], which the Copernican canons make smaller by $\frac{1}{2}$ second [scruple]. Likewise, at the same time the observed diameter of the Moon was $32\frac{1}{2}$ minutes [min. $32\frac{1}{2}$]; this too the Copernican reckoning requires to be scarcely the half of one minute narrower. The altitude of the center of the Moon, when the foregoing observation was made, was about $49\frac{1}{2}$ [$49\frac{1}{2}$ proximè].

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V.

On 24 October of the same year, at hour 6, minute 12 after midnight, when the Moon was set at 90° from the horizon, it was found — both apparently and truly — to hold 27 parts, 5 minutes of Cancer [part. 27. /.5 ☿]. Its apparent latitude was likewise found to be 5 parts, 50 minutes [P.5. /.50]. But the true latitude was 5

parts, 9 minutes [part. 5. /.9]. Therefore, when this is subtracted from the apparent one, the parallax I was after springs out at 0 parts, 41 minutes [part. 0. /.41], which agrees with Copernicus's view to the very second [scruple]. So too the diameter of the Moon was at that time observed as 33 minutes [M.33], which he increases by at least $\frac{1}{2}$ second [scruple]. The altitude of its center was then about 49 [part. 49 circiter].

VI.

On the following day, which was 25 October, at hour 7, minute 29 P.M.N. [past midnight], the Moon again stood at a quadrant's distance from the point of the ecliptic rising at the horizon, and from observation it had its longitude — both apparent and true — at 11 parts, 10 minutes of Leo [in part. 11. min. 10 ϱ]. Its latitude was noted at 5 parts, 30 minutes south [part. 5. /.30 Merid.]. But since the true latitude, by our calculations, was 4 parts, 45 minutes [part. 4. /.45], the parallax of the Moon was 0 parts, 45 minutes [part. 0. /.45], which also agrees with Copernicus's computation closely enough to the second [scruple]. The altitude of the Moon was then about 45 [P.45 proximè], and it had an apparent diameter of about 34 minutes [M.34 proximè]. None of this departs from his presuppositions.

I have now reviewed six special observations, made with my own instruments, from which I investigated the parallax of the Moon. Since it agrees as closely as possible with the values that the Copernican reckonings require at a comparable altitude, it is reasonable that the parallaxes of the Moon should come out in this way — and consequently that its distance from the Earth, set above [in the work], is not unsuitably determined. I have chosen to confirm this by these six observations of my own.

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It must be noted, however, that everywhere we have used the true latitude of the Moon not according to the common reckoning — which presupposes the maximum deviation from the ecliptic to be precisely 5 parts — but rather according to our own findings, which make that same [maximum] larger by a quarter of a degree. And if anyone examines everything more carefully — whether from these few observations just indicated [or otherwise] — he will recognize that the latitude of the Moon, as corrected by us, holds good in proper fashion, but that the old [value] by no means agrees. This I judged worth pointing out in passing; elsewhere I shall bring forward clearer examples in testimony of the matter.

Since, then, it is clear from experience itself that the lunar parallaxes and distances are not incongruous — assuming, that is, those that have been laid down by practitioners, especially Copernicus, and as has been plainly demonstrated above — it is least of all possible that this New Star admitted so great a parallax, indeed any parallax at all, such that it could have occupied a place below the Moon or near it.

That the Sun's assumed distance from the Earth is also well founded, the lunar eclipses sufficiently prove. For to perceive this same thing through the Sun's parallaxes is too uncertain — though we have not left even this untried — and we have ascertained, as far as could be done, that things agree with the presupposed distance; so that there is no doubt that the Sun's apogee lies away from us at as great an interval as we have stated. And therefore that conclusion too which, regarding the New Star, we drew by suitable reasoning — namely that it was by no means below the Sun — deserves no hesitation.

There now remains the other matter to be resolved, concerning the refractions noted hitherto by very few. This [I shall treat], so that it may be done [in fewer words]...

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[so that it] could be done [in fewer words]. For since, in Chapter Two, from what we set out concerning the refractions of the fixed stars, it is sufficiently clear that around 20° of altitude they become imperceptible, there is no doubt that at the least altitude — near August [i.e., near its lowest meridian passage] — [the Star] was subject to no perceptible refraction, because the Star was on that horizon when, in the meridian below the pole, it rose a little beyond 20 degrees. Far less so here in Denmark, where it did not come within about 28 parts of the horizon. For that reason, neither here nor anywhere in all Germany, when it was at its nearest descent, did it betray any sensibly perceptible refraction. In Spain, perhaps, where Munosius [Jerónimo Muñoz] observed it at its nearest elevation — at least $11\frac{1}{2}$ parts — it could have introduced a slight refraction; yet this was extremely small, and except with instruments graduated most minutely it scarcely showed itself.

Therefore, since the refractions could bring in no element of doubt against the things we have demonstrated concerning the insensibility and absence of any parallax of this Star, it is manifest that all those things stand exactly so, and that no just occasion for contradiction remains.

That this Star, then, had no parallaxes at all, and that it stood exalted above the boundaries of all the planets, in the very firmament, among the rest of the fixed stars, throughout the whole time of its duration — just as we set out to demonstrate and explain clearly in this Sixth Chapter — we are confident has by now been so sufficiently established that there is no room for evasion among those skilled in mathematics. Therefore, with these defenses against any attacks thus fortified and left secure, let us hasten on to the matters that concern the true magnitude of the Star.

CHAPTER [SEVEN]

CHAPTER SEVEN

On the true magnitude of this new star, which it had in the sky itself, presenting first the magnitudes of the other celestial bodies too, both from the determinations of the ancients and from my own observation.

It might indeed seem unusual to fix a settled magnitude for a body so far removed, at so immense a distance, and altogether inaccessible — when even the objects that are on the Earth, and lie close at hand to our sight, are subject to some difficulty in this respect unless the sighting line of the measurement is set up accurately. Yet in truth, if the visible diameter of the star, together with its distance from the Earth, can be brought into the open, then it is not beyond geometrical reasoning to disclose its fixed magnitude — the magnitude which the star holds in the very place where it exists. This is just what Ptolemy and Copernicus long ago did in measuring the luminaries [the Sun and Moon], and what al-Battānī [al-Battānī] and al-Farghānī [al-Farghānī] did for the rest of the planets and for the fixed stars.

Since I am about to treat the true magnitude of this New Star, I think it not out of place first to present the relative measurements of the other heavenly bodies, both according to the ancients and my predecessors and according to my own views as well. This will give readier access to the matter I am aiming at, and will let the comparison of the magnitude of the New Star — which is my chief concern — with the other principal visible bodies of the world be made more conveniently.

On the Sun and Moon, with their magnitudes compared with respect to the Earth and to each other, according to Ptolemy and Copernicus.

Ptolemy [Ptolemy] carefully investigated the true magnitudes of the luminaries, making the comparison both with respect to one another and also with respect to the Earth. He did this chiefly by means of lunar eclipses, using the conical form of the Earth's shadow, together with the various cross-sections it presents, and combining this with the apparent diameter of the luminaries to make the matter clear. He declared the Sun to be larger than the Earth by 166% — for he found the ratio of its diameter to the Earth's to be as 11 to 2. The Moon, on the other hand, he found smaller than the Earth, very nearly 39 times — so that the ratio of the diameter of the Earth to that of the Moon would be as 17 to 5. From this it follows that the Sun's bulk turns out greater than the Moon's by about 6540.

Al-Battānī and al-Farghānī agree very nearly with Ptolemy in these matters. For that reason I judge it superfluous to repeat their pronouncements on these points.

Copernicus [Copernicus], setting these things out somewhat more precisely, established the Sun to be larger than the Earth by about 162 — so that the ratio of the diameter of the Sun and of the Earth is as 5 p. 27 m. to one. He held the Earth in turn to be larger than the Moon by very nearly 43, the ratio of their diameters standing as 7 to 2. And so the Sun's bulk exceeds the Moon's by almost 7000 times.

The discrepancy that lies between these three craftsmen in measuring the principal visible bodies of the world is not so great that they should not readily earn their excuse from anyone who rightly esteems the subtlety of their work. Indeed, the measurement and knowledge of these bodies and their proportions is not very difficult, since the visible diameters — owing to their evident magnitude — are amply accessible to observation, and the distances of the luminaries from one another can be obtained from lunar eclipses, by means of the Earth's shadow, as I have said. I pass over the fact that they can be examined from the parallaxes, especially the Moon's, when these are precisely investigated, since it is not far from the Earth. But in the case of the remaining planets, since these two things are not so readily granted, there is greater difficulty; and the difficulty is far greater still in the fixed stars, on account of their excessive distance from our gaze.

For this reason Ptolemy and Copernicus occupied themselves with determining the true magnitude of the luminaries at least, deliberately passing over the rest — both the wandering stars [planets] and the fixed stars.

On the magnitudes of the other five planets, and also of the fixed stars, according to al-Battānī and al-Farghānī.

The Arabs al-Battānī and, after him, al-Farghānī did not leave these stars untouched either. Rather, working out the greatest and least distances of the planets according to the Ptolemaic hypotheses, and from these gathering the intermediate ones, and then placing the sphere of the fixed stars immediately above Saturn, and applying in every case a visible diameter accepted (as it seems) by estimation, they reasoned about the planets' true magnitudes. Al-Battānī sets this out clearly in Chapter 50, and al-Farghānī in Difference 22 (*Almagest*-tradition reckoning). So that their view on these matters may be more readily known, I shall review it briefly. Afterward I shall disclose, all in one place, my own observations, which differ not a little from their opinions. I shall by no means pass over the luminaries either, as the chief bodies — and most of all the bodies of the world that fall under our senses — about which alone Ptolemy and Copernicus busied themselves in this discipline. Then, when the New Star too had been measured according to its proper reckonings, I shall set up a comparison with the Earth and the Sun and with the ordering of the fixed stars, in proportion as it was approximated to them as it diminished — for this represents the magnitude of all the rest, though at a different time of its duration.

And so I shall cross over for a little while to the things that al-Battānī and al-Farghānī, following the view of the ancients who came after Ptolemy, set down in writing concerning the magnitudes of the remaining wandering and fixed stars. For although this may seem to wander further than is right from my undertaking, nevertheless I judge it neither foreign nor useless to mingle in these things too (since I do not wish to confine myself perpetually within the bounds of the adopted celestial phenomena in this work, but rather, whenever occasion offers, to bring in benefit from the rest of astronomy as well, as I determined from the outset).

Indeed, I shall not merely report the bare opinion of the ancients on the magnitudes of the stars: I shall afterward examine in what part it holds true and in what part less so, and shall compare it, all together, with my own findings. Now, therefore, let us look into what the ancients thought on these matters; and,

beginning from the star Mercury — just as they too did — let us ascend through the remaining planets all the way up to the most remote sphere of the fixed stars.

Al-Battānī reports the star Mercury, in its mean elongation from the Earth — which he places, according to the Ptolemaic hypotheses, at 1.115 — to have, on careful

(continuing) inspection, a visible diameter equal to the fifteenth part of the Sun's diameter. From this he gathers that Mercury is about nineteen thousand times smaller than the Earth. Al-Farghānī supposed it to be at least the 22000th part of the Earth.

The star Venus, in its mean distance from the Earth of 618 semidiameters, he declared to appear as the tenth portion of the Sun's diameter. Accordingly its own size carries the 36th part of the Earth, so that the ratio of the diameters is as 10 to 3. Al-Farghānī has it that it is smaller than the Earth by 28, but elsewhere 37.

Mars, when it stands at a middling distance from the Earth, is about 4584 semidiameters away. He held that it then equals the twentieth part of the Sun's diameter, and on that account once comprehends the whole magnitude of the Earth, and besides nearly a third part of it — so that the diameters stand to one another as 7 to 6. Al-Farghānī sets Mars at one and a half times larger than the Earth, together with an eighth part.

The star of Jupiter al-Battānī removes to a mean distance of 10423 semidiameters, and asserts that it then represents the twelfth part of the Sun, and on that account exceeds the Earth in its own magnitude by 81. Al-Farghānī has 95, which fits better — so that the ratio of the diameters of Jupiter and the Earth is as 32 to 7.

Saturn he places at about 15800 in mean longitude, and gathers it to present the eighteenth part of the Sun, and from this to exceed the Earth by 79. Al-Farghānī has 91. From this the proportion of the diameters would come out as 9 to 2.

These, then, are the matters concerning the five planets handed down in this manner by these ancients. Now let us also disclose what their opinion was concerning the magnitudes of the fixed stars.

Al-Battānī likewise supposed the sphere of the fixed stars to be removed 19000 semidiameters of the Earth; and this is not incongruous, if the Ptolemaic hypotheses were free of every doubt. For there Saturn is at its greatest apogee, and is elongated from the Earth about 18500 semidiameters. And it is reasonable that some space should lie between the Eighth Sphere and Saturn — although al-Farghānī raises the fixed stars higher. He next established that the fixed stars

which are of the FIRST magnitude exhibit the twentieth portion of the Sun's body, and therefore, by the ratio of their distance, are larger than the Earth by 102. Al-Farghānī gives 107 — so that, according to him, the ratio of the diameter of these stars with respect to the Earth stands as 19 to 4.

Afterward al-Battānī passed on as far as the stars of the sixth magnitude, which he says surpass the bulk of the Earth 16 times. But al-Farghānī also explains the magnitudes of the intermediate ranks, in such a way that those of the SECOND order are ninety times [the Earth]; those of the THIRD, seventy-two times; those of the FOURTH, fifty-four times; those of the FIFTH, thirty-six times;

makes them six times larger; the stars of the sixth rank, by contrast, he makes eighteen times larger than the Earth. In none of these cases does he seem to have applied any specific and proper measurement; rather, he distributed these magnitudes by a rather rough estimate, or indeed by an arbitrary reckoning. For he assumed that the stars of the first rank were 107 times larger than the Earth (as I have said). He divided that number into six parts, and then, for the successive ranks, he progressively subtracted this sixth part each time. From this it came about that the stars of the remaining magnitudes are supposed to obtain the sizes he assigns them, and that for the stars of the last and smallest rank — that is, those of the sixth magnitude — that excess of eighteen-fold over the terrestrial globe is left. Whether this arrangement was set out by a just or an unjust distribution I will not say for now; but I will later state my view on these matters briefly.

These figures are established in this way both for the planets and for the fixed stars, according to the views of those authors. And indeed, as far as the visible diameter of the stars is concerned, when the comparison is made against the Sun, they do not seem to have strayed much from the mark. But since they relied too heavily on Ptolemaic hypotheses in inferring the distances of the planets, the sizes that they then derive from the apparent diameters do not come out correctly either — so much so that the bodies of Venus and Mercury do not turn out to be nearly as much smaller than the Earth as they should. So too, in the case of the three superior planets, a clear discrepancy is found if their distances are adjusted to fit our own hypothesis — from which, moreover, the Copernican view differs only very slightly. These same earlier astronomers also attributed excessive magnitudes to the fixed stars, since they raised their sphere away from the Earth by at least 5000 [Earth-]semidiameters too far, as will appear later.

So that the students of these arts may grasp the matter more correctly, let me explain in brief the method and the procedure of demonstration that al-Battānī

[al-Battānī] chiefly used in determining the magnitudes of the stars, given their distance and the visible diameter expressed as some fraction of the solar diameter, according to its apparent size. I do this all the more because the substance of his demonstration and procedure is somewhat obscurely set out, both by al-Battānī himself and (especially in this passage) by his expositor, Regiomontanus [Regiomontanus].

Suppose, then, that in the following figure A E is the mean distance of the Sun, whose apparent semidiameter is E C in its own sphere. Take, for example, A F as the distance of Saturn, at which the Sun's semidiameter would come out as F G; and suppose that, as seen there, F D is taken to occupy the eighteenth part of the apparent semidiameter of the Sun. Then, as E A is to E C, so A F is to F G. It will therefore be established that F G — of which the eighteenth part is D F — is the semidiameter that exhibits the true semidiameter of Saturn in terms of Earth-semidiameters. In the same way, if the Sun's semidiameter is taken as F G, and B E is that of Venus or Mercury lying below it, then, since as A F is to F G so A E is to C B, the Sun's semidiameter will be presented in terms of Earth-semidiameters, in the assumed

distance of Venus or Mercury. And from this, once the appropriate portion has been separated off — a tenth for Venus, or a fifteenth for Mercury — the magnitude of either of them in terms of Earth-semidiameters becomes known. For the fixed stars too the reckoning was carried out in no other way than was stated above for Saturn.

Diagram. A geometric figure illustrating al-Battānī's method for deriving the true sizes of the planets from the apparent solar diameter at their distances. A large right-triangle-like construction runs from a point A at the far right (the eye/vertex) along a long base line to the left, where a small circle (the Earth) is drawn at F. From A, a long upper line rises to G at the upper left. Vertical line segments drop at intermediate points.

- A (far right): vertex / point of sight
- G (upper left): top of the construction, defining the Sun's semidiameter F G at Saturn's distance
- D (left, below G): foot defining D F, the eighteenth part of the Sun's apparent semidiameter
- F (lower left, with small circle): the Earth's position; foot of the segment F G
- C (middle, on the upper line): point defining the Sun's apparent semidiameter E C

- B (lower middle): point on the base line, with C B as Venus/Mercury's semidiameter
- E (lower middle, with small circle, just below B): foot of segment E C; mean distance A E of the Sun

Moreover, there is one further point that the ancients, who vainly built up the reality of the celestial orbs, failed to consider, and it deserves notice: namely, that the fixed stars need not all necessarily be removed from the Earth at an equal distance. For some of them may well be higher than others by a great interval — since it is not established how vast that expanse of heaven is which they occupy. And so, since they are (no doubt) unequally removed, definite magnitudes cannot be assigned to the individual stars from their visible diameter by any fair determination, because the difference of the intervening intervals is beyond investigation. It can therefore happen that some stars, which appear smaller to us, are in reality equal to others that appear larger — and, by the same token, that they appear smaller to us merely because of their higher position. And the same conclusion follows for the rest.

Indeed, even if they were all situated at an equal distance in the same sphere, still those that are reckoned to be of the same rank do not all have an exactly equal apparent diameter. And so a closely similar magnitude does not belong to each of them in the same way. For Sirius [Sirius] and Vega [the Lyre / Fidicula] are seen as much larger than Aldebaran [Aldebaran], and this last star in turn appears larger than Regulus [Regulus] and Spica [Spica / Arista] — even though all of them alike are reckoned of the first magnitude. So, however equally distant they may be from us, the stars Sirius and Vega will still be much larger than Aldebaran [Palilicium], and this latter will exceed Regulus and Spica of Virgo. The same judgment is to be passed on the rest.

But since we shall treat this subject more fittingly and more fully in another place at some point, we are unwilling now to digress too far beyond our purpose.

Before, then, we set forth our own conceptions concerning the altitude of the fixed stars and their magnitude — both apparent and true — conceptions by no means in agreement with the views of the ancients, it seems worthwhile first to establish the proper commensuration of the intermediate planets, in accordance with our own reasoning as well,

so that, ascending little by little through the regions of all the planets, we may at last arrive at the highest, the eighth sphere.

First, then, as regards the two luminaries and their comparison both with the Earth and with each other: since the supreme masters Ptolemy [Ptolemy] and Copernicus [Copernicus] have treated this point clearly and carefully, and since the difference that arose between them in this respect need not be reckoned significant, and since they did not stray far from the mark either, I do not wish to dwell at length on the matters I might add concerning their magnitudes. Nor do I wish now to set up a more accurate determination from lunar eclipses, as was done by them — for that belongs to another place, and here, by its prolixity, it might perhaps cause distaste.

Rather, using a certain briefer method, by a procedure not unlike the one we use for the other stars and the planets, we shall reason out the true bulk of each from its visible diameter and its distance, in the manner that follows.

The Author's Estimate of the Magnitudes of the Celestial Bodies; and first, of the Two Luminaries, the Sun and the Moon

We have long and thoroughly scrutinized the apparent diameter of the Sun with the most careful instrument, especially by means of a tube about 32 feet long, and that at both solstices — when the Sun appears smallest in summer but largest in winter — as well as around the two equinoxes, when it is at its mean state, and likewise at other places in the zodiac. Nor was I ever able to find, even at the apogee itself, when it is positioned near the beginning of Cancer, that it appears larger than 30 minutes; indeed, I noticed that even then there were sometimes a few seconds wanting to complete a half-minute. Around perigee, by contrast, near the beginning of Capricorn, I have found that it exceeds 32 minutes in its visible magnitude — so that here too scarcely a few seconds are left over. A little after each of the two equinoxes, when the Sun presents itself to the eyes at its mean quantity, I found that it very nearly completes an apparent magnitude of 31 minutes. And this also holds by a mean ratio between its greatest and least visible quantity — which we shall also use in investigating its true magnitude.

Nor do we make any difficulty over the fact that Copernicus, after he had in his own way set certain limits to Ptolemy's views on these matters, asserted that the Sun presents at apogee 31 minutes 49 seconds, at perigee about 34 minutes, and at the mean 32½ minutes. For we do not, on anyone's authority, think it at all advisable

to depart from experience itself, when it directly bears on the senses — however closely the Alphonsine [Alphonsine] assumptions may agree with the Copernican ones, and however far both of these may diverge from Ptolemy's own views, which are marked out as if they were peculiarly his. For this reason the visible diameter of the Sun is everywhere supposed somewhat larger by all of them than our own experiment yields. Standing rather by that experiment, we have firmly maintained that the Sun, when removed from the Earth at its mean state, does not complete more than 31 minutes in its visible diameter.

As for its distance from the Earth, which Copernicus then wished to be 1142 semidiameters (a figure that we too, for the most part, have used in what precedes wherever there was need, since the discrepancy from the truth is small) — Ptolemy, however, set it somewhat larger, namely growing to 1165. Here we prefer to assume the same as 1150, as being roughly intermediate between the removal of Ptolemy and that of Copernicus, though inclining toward the latter rather than the former. The reasons for this assumption we have resolved to give elsewhere, for it would be too perplexing and prolix a matter here.

And certainly, for embracing this distance as the truer one (since it agrees as closely as possible both with our observations, accurately made and demonstratively examined in eclipses), I was elsewhere drawn — not unwillingly — by certain reasonings of mine, drawn from the symmetry of the bodies of the universe and their magnitudes, and adapted together with the mysteries of numbers. To this same view a certain pamphlet once published by Johann Franz Offusius [Johann Franz Offusius], a German, *On the Divine Faculty of the Stars*, also invited me. For there, while he reckons the distances of the celestial bodies from the Earth in a certain harmonic and proportional way — not, however, to be disapproved everywhere — he infers, not unskillfully, that the Sun is removed from the Earth by 576 whole terrestrial diameters. And he does this especially for this reason: that he may conveniently adapt to this measurement that sacred number, celebrated elsewhere among the Pythagoreans and Platonists — since both the appearances in the solar motion of themselves, and those that are seen in eclipses, in no way contradict this arrangement. Indeed, more exactly than Ptolemy's or Copernicus's views maintain, they agree here — as will appear in due time from our observations.

Not unwillingly, then, shall we lend our support to this Offusius in this part: namely, that the Sun, according to that mystical number 576, when it presents itself at its mean state, is distant from us by [576] terrestrial diameters. And if these are doubled, they will yield, in either case, 1152 semidiameters of the same

Earth. But lest we should seem to bind these matters too scrupulously or superstitiously to those Pythagorean numbers, we have preferred — setting aside those two semidiameters, as being of themselves insensible in such a business — to accept exactly one hundred and fifty beyond the thousand semidiameters. This will nonetheless furnish sufficient precision for our purpose.

We have therefore assumed the Sun's apparent diameter to be exactly 31 minutes, in accordance with its mean distance from the Earth, which (as already stated) amounts to 1150 semidiameters. From these we shall arrive at a knowledge of its true diameter and bulk [corpulentia] as follows.

Diagram. At the upper left of the page is a geometric figure showing the body of the Sun and the cone of vision converging on the eye at the Earth. A circle (the Sun's disk) is drawn with a horizontal diameter and a vertical diameter crossing at its center. From the two ends of the horizontal diameter, two long lines run down the full height of the page and converge to a single point at the bottom (the observer at the Earth). The labels read:

- E (top of the circle): the upper extremity of the vertical diameter
- B (center of the circle): the center of the Sun's disk
- D (left end of the horizontal diameter): one end of the Sun's diameter
- C (right end of the horizontal diameter): the other end of the Sun's diameter
- A (the convergence point at the foot of the two long lines): the eye of the observer at the Earth

In the text the Sun's body is designated D E C, its diameter D C, the angle subtended at the Earth is D A C, and the Sun's distance is the line A B.

Let the body of the Sun in the figure as drawn be D E C, whose diameter D C produces the angle D A C of 31' at the Earth, the point A; and let the Sun's distance A B contain 1150 semidiameters of the Earth. Now, in a rectilinear triangle two equal sides about a known angle are given (for D A and C A here differ imperceptibly from A B), and so the third side cannot but be about 11 [Earth-]semidiameters and 22 1/2 [minutes? — recte: a fraction], that is, 11 [parts] and 22 1/2/[?] nearly. [recte: "11 / 22 1/2" — the printed figure reads "p. 11 / 22 1/2 ferè," giving the Sun's diameter as about 11 1/5 Earth-semidiameters; see Parsing note below.] The Sun's diameter therefore contains just so many Earth-semidiameters. Consequently it is larger than the whole terrestrial diameter five times over, and by a further 14/25 besides — that is, nearly by a fifth-and-a-sixth part of one [diameter]. If these numbers are resolved into cubes, and the larger

cube divided by the smaller, the true bulk of the Sun in relation to the Earth will emerge. For spheres stand (according to what Euclid demonstrates in the last proposition of Book XII) in the tripled ratio of their diameters [Euclid, *Elements* XII, final proposition]. Once this operation has been carried out, it will be evident that the globe of the Sun is 139 times larger than the terrestrial one, and a little more.

But so as not to seem to pry into these matters too minutely, we shall set the Sun down as 140 times larger than the Earth; and in so doing, if its true magnitude is anything at all to be preferred [over our figure], we have erred in nothing of any moment. For it cannot be larger than this, but rather somewhat — if at all — smaller.

Nor are we in the least troubled that Copernicus [Copernicus] made it the same 22 terrestrial globes, and Ptolemy [Ptolemy] more still, namely 26, larger. For since they enlarged its visible diameter somewhat beyond what is just, it necessarily followed that they enlarged its true diameter too, and hence its whole bulk in relation to the Earth, growing somewhat beyond the proper proportion. I say nothing of its distance from the Earth, which they did not presuppose in the same way as we do here. Indeed, if we apply the Copernican mean distance of the Sun, which is 1142 Earth-semidiameters, to the visible diameter of 31 minutes that we have assumed, the Sun will not turn out to be larger than the Earth a full 137 times, but a fourth part will still be wanting. Yet the earlier reasoning derived by us — which [establishes] the Sun's true magnitude

— by a comparison made with the Earth (so far as that can be done), determines this precisely enough. And so much for the Sun; now we shall add the commensuration of the Moon as well.

In setting out to demonstrate the magnitude of the Moon — which can be drawn from eclipses concerning it, and confirmed in finer detail by means of its parallaxes (as to its distance), or even transferred here from the very hypothesis of its motion — I do not wish at present to investigate the matter subtly, since that would be too long an undertaking. Nor do we here aim at the highest precision, which calls for a more intricate demonstration and more requisites; but only at what, by a broader inquiry, can come nearest to our purpose. And so as not to dwell here at length — since from what precedes, where we treated of the Sun, the method of demonstration and of operation has been sufficiently indicated — we shall dispatch this business briefly.

Presupposing that the Moon, when it is about 60 Earth-semidiameters distant from us, presents a visible diameter of its body of 33 minutes (which agrees with observation), the Earth's diameter will contain the Moon's diameter three times and $\frac{23}{43}$. Thus the proportion of the lunar diameter to the terrestrial will be roughly such as 2 to 7 — that is, two-sevens-and-a-quarter [recte: "se miquadrupla," i.e. about one part to three-and-a-bit] — or, if one prefers to examine the matter more exactly in the customary measure of miles, by setting the terrestrial diameter to contain 1720 miles [milliaria], the lunar diameter will come out from the same [figures] as 495. And so, when the ratio of these diameters to one another in numbers is taken cubically and (as was said before) distributed, it will be established that the globe of the lunar body is nearly forty-two times [quadragies bis] smaller than the terrestrial bulk. As for the Copernican finding on these same matters, it comes very close, and does not depart greatly from the Ptolemaic.

Let it suffice to have shown briefly in this place these things concerning the visible and true diameter and the bulk of the [two] luminaries in relation to the Earth. From them it also becomes clear to an attentive reader, on comparing these two lights of the world with one another, that the proportion will be such that the true diameter of the Sun contains the lunar one exactly eighteen times; and that on this account the globular body of the Sun is larger than the lunar one by 5848 [times]. So that, not quite according to this reckoning, the Sun exceeds the Moon six thousand times — whereas Ptolemy supposed it to be still beyond that, by more than five hundred times. And Copernicus reckoned the Sun nearly 7000 times larger than the Moon.

Now this very point — that we said the lunar diameter is contained 18 times in the solar — also fits aptly with the diameters of the orbs which they describe by their revolution about the Earth, especially as regards their greatest remove from it. For if we assume the Sun to be distant from the Earth at its mean by (as already indicated) 1150 [semidiameters], its greatest distance will be 1190, just as its least is nearly 1110, according to our findings in the Apparent [positions] concerning it. And since the highest Moon, by Copernicus, is removed about 63 [semidiameters] from the Earth,

68, this number will be contained here as nearly as may be 18 times in the greatest distance of the Sun already indicated. And if we bring into the reckoning the greatest elongation of the Moon from the Earth, according to Ptolemy's hypotheses — which is about 64 Earth-semidiameters — and, limiting the artificer's assumptions on both sides, take the mean of this and of the greater

removal of the Moon from the Earth at its greatest digression, this number will likewise be precisely 18 times [contained] in the aforesaid greatest sublimity of the Sun's sphere. It is plain, then, that the sphere of the Sun comprehends the lunar one in its diameter exactly 18 times by this reckoning — just as the diameter of the body of the Sun likewise contains the diameter of the Moon 18 times over. A fine and elegant symmetry, indeed, and one not (so far as I know) considered by anyone hitherto. And if all things were to be weighed by an exact balance (which we have resolved to do in a more suitable place), perhaps both these matters and many others would lie open, attesting to the admirable and supreme wisdom of the Maker [Opifex] — even in this very proportion of the world's bodies — and would become more fully and more accurately manifest. These things it has pleased us to touch on here only lightly, and with a duller [pen of] Minerva. Now we shall go through the magnitudes of the remaining five planets, making a comparison with the Earth in like manner.

De reliquorum QVINQUE PLANETARVM Quantitatibus, Autoris opinio.

[On the magnitudes of the remaining FIVE PLANETS — the Author's opinion.]

Beginning, then, with Mercury [Mercury]: just as earlier, when we set out the opinion of the Ancients, [we noted] that its visible diameter, when it appears far digressed from the Sun and is removed about the same amount from the Earth, has on several attentive inspections been found to be $2 \frac{1}{6}$ minutes — which differs imperceptibly from the annotation of the Ancients. For if it were not so near the Sun that the view of it were impeded by the morning and evening twilight, it would be seen to surpass the stars of the first rank [in brightness]. And since, when placed about the same [distance], it stands off from the Earth nearly the same 1150 semidiameters, by geometrical reckoning the proportion of its diameter to the Earth's diameter will be found such as 3 to 8. And when this has been expanded cubically and distributed, it will be manifest that the star of Mercury is at least 19 times smaller than the Earth — although the Ancients asserted that it was surpassed by it some several thousand times over.

The gentle radiance of Venus [Venus] we have for the most part observed, about its mean elongation from the Earth, to occupy a diameter of $3 \frac{1}{4}$ minutes — which exceeds the assumptions of the Ancients somewhat. And since at that time it likewise stands off from the Earth nearly as the Sun does, namely 1150 Earth-semidiameters — as does Mercury too (of which we just spoke) — there emerges

by geometrical computation a ratio of the diameter of Venus to the diameter of the Earth such as 6 to 11. And therefore, by cubic aggregation, the star of Venus will turn out, in respect of the Earth's globosity, to be at least six times smaller than it, with a $\frac{1}{3}$ [over] — whereas in antiquity it was thought to be only a thirty-sixth part of it.

From these things it is evident that the Ancients, in comparing the bulk of these two planets [Mercury and Venus] with the Earth's globe, made it too small; and this befell them because they supposed both to be placed below the Sun, and Mercury to be just above the Moon. Thus, by bringing them too near the Earth, they admitted their true diameters as smaller than was proper — exactly as we ourselves intimated earlier. But in the case of the other three, the higher planets, they erred in the contrary manner, raising them farther from the Earth than they ought; and hence they made these too large as well, as we shall now see.

The visible diameter of the star of Mars [Mars], when it is removed from the Earth at its mean, we have observed to be not quite 2 minutes, falling short by about a third part of one. Its distance from the Earth at that time is, according to our reckonings, about 1745 semidiameters. Its diameter will therefore occupy at least $25\frac{3}{7}$ of the 60 parts of the Earth's diameter. By cubic computation, then, the Earth will be something more than thirteen times larger than Mars — whereas the Ancients supposed it to be smaller than [the Earth] by nearly one-and-a-half times this [factor].

Jupiter [Jupiter], that brilliant heavenly body, when it is at its mean distance from us — which embraces 3990 Earth-semidiameters — we have ascertained to fill in visible diameter about $2\frac{2}{3}$ minutes. From this it follows that its diameter stands to the Earth's diameter as 12 to 5 nearly. And therefore [Jupiter] is larger than the Earth by about 14 times — whereas it was once thought to surpass it by more than eighty times.

Saturn [Saturn], that lofty star, when it holds its mean distance from the Earth — namely 10550 semidiameters — visibly fills nearly 1 minute 50 seconds. From this it follows that its diameter contains 2 of the Earth's diameters, with about $\frac{7}{12}$ [recte: $\frac{7}{?}$] besides, so that the proportion of the diameter is such as 31 to 11. The cubic ratio, then, will show that it exceeds the Earth by a little more than 22 times — without regard to the fact that antiquity put it forth as larger than the Earth above ninety times.

In this manner (as has been said) stand the magnitudes of these five erratic [stars] compared with the Earth, according to our modern observation, founded

also upon our own hypotheses. From these it appears that the Ancients enlarged the three we call the higher planets with excessive magnitude, but made the two lower ones smaller than was just (as we intimated before as well).

Having thus, by this route, surmounted the boundaries of all the planets, we shall now climb higher, to scrutinize by like reasoning the magnitudes of the fixed stars [Affixae Stellae]. And so that this may be done more conveniently, it will first be worth our while to make known how far the star of Saturn, when it is most exalted from the Earth, departs hence. And we shall now expound this according to that part of our hypothesis which is chiefly required here.

In accordance with our own newly devised arrangement for the revolutions of the celestial bodies, we hold that the Earth is the center only of the two luminaries and of the eighth sphere, whereas the Sun is the center of the remaining five planets. We have laid out the design of this newer ordering — just as we shall do in the following book, on the occasion of the comet of the year 1577, so that we may frame from it some hypothesis not at all unlike those for the planets — and we share it, with a more general explanation added, with students of astronomy. For now, however, we shall here unravel at least that part of it which reaches as far as the circuit of Saturn, and only to the extent needed (as I said), so that the supreme elongation of Saturn from the Earth, according to our reasoning, may stand out more readily. From this the distances of the fixed stars, together with that of this New Star [New Star of 1572] — for whose sake we have undertaken to disentangle all of this — may be set out more correctly.

Let it therefore be understood, in the figure that follows, that A is the Earth, the center of the universe. The outermost is the starry orb, which is represented immediately above the revolutions of Saturn by S T V X, and which is also commonly called the eighth sphere; on every side, according to both the reckoning of the ancients and our own, it is equally far from the Earth. Within this orb and the Earth, the rest of the wandering stars — which we call planets — continually carry out their manifold, tireless, and admirable revolutions. The Sun's annual orb is B C D E, described likewise about the center A; for here we have not thought it necessary to take account of the solar eccentricity. The Saturnian circuit, which moves about the Sun (as do the circuits of each of the other four planets, according to our hypotheses), is marked F G H I, with B as its center, that is, the Sun (as I said). Because of its great vastness, Saturn finally completes its circuit in its thirtieth year, so that its center is carried around together with the Sun nearly thirty times in the annual orb B C D E during the time that the body itself passes once through this larger and proper orbit.

But Saturn's star is not carried around in this orb in a simple manner. Rather, it moves with a motion doubly compounded — a motion which the ancients tried to account for, too crudely, by means of an eccentric and an equant, with an awkward fit as regards mathematical regularity. We, by contrast, shall account for it more suitably by means of two small circles fitted to that same orb. The first and larger of these, which I choose to name first, is N K L M, drawn about the center F on the circumference of the primary orb itself. The second and smaller, which is called the second, is O P Q R, drawn about the center K on the circumference of the first; near its periphery Saturn's star itself is understood to be carried. And this proceeds by the following rule: while the center of the star, K, passes once through the first small circle K L M N, Saturn's star itself completes two revolutions in the smallest little circle, and the first small circle [completes its revolution] likewise together with the orb of Saturn itself. The center of the larger small circle is, moreover, to be set moving in the order of the signs [in Signorum consequence] through the Saturnian orb itself; but the center of the smaller is to be moved in the contrary direction, on the periphery of this first one, and thus deflected in the order preceding the signs, against the motion of the principal orb. In the same way again the planet performs its circuit in the smallest, or second, small circle consistently — against the motion of the center of that same circle in the first and larger one. And since this center is to be understood as twofold with respect to the motion of its own center in the first little orb, it comes about that as often as the star is set at apogee or perigee near K M, it is always close to Q, near the center F of the first small circle. But in the middle quadrants, near N and L, it is everywhere near O, in the position of greatest distance from the center of the larger small circle.

It will, moreover, be necessary that the planes of these two small circles coincide entirely in one and the same plane with the plane of the more principal orb. For the fact that the star departs variously in latitude from the ecliptic takes its occasion not from this, but from elsewhere — a matter to be discussed another time, when these things come to be treated fundamentally: that is, when, in a special astronomical work, with the favor of the Maker of things celestial and terrestrial, we shall set out professedly the agreement of our hypotheses with the celestial appearances. For then all those things — some of which are now recalled only in part, concerning the motion of Saturn's star in longitude, arising unequally on account of the involvement of the aforesaid small circles — will be brought clearly into the open: together with that anomaly which arises by reason of the annual revolution of the center along with the Sun (whence come the stations and retrogradations, and other matters of the same kind, by which the

inequality of the apparent supervening motion is accounted for), more fully and more perfectly, along with the explanation of the cause of the things that depend on both latitudes.

For now, at least, it has been allowed to touch on these things only with the topmost lips, and so far as was necessary for our purpose: namely, to set out, as was here chiefly required, the magnitudes and symmetries of the orbs, both the larger and the smaller, in whatever way might be convenient. I shall here use the same proportion of commensuration that Copernicus [Copernicus] employed, though adjusted to the reckoning of our own assumption. For although these matters stand somewhat otherwise according to Saturn's own appearances — according to several observations made in preceding years, which Copernicus, having borrowed most of his measurement from Ptolemy [Ptolemy], reports — nevertheless, since the difference is so small that it cannot perceptibly disturb our present intent, in this place we shall be content with the Copernican distribution of magnitudes alone. For it is less opportune to disclose our own [reckonings] within these limits now, since that would be a matter of higher and longer business. Indeed, many other things remain to be explained and unraveled together, which are not of this place and time, and which are to be shared elsewhere, by a more convenient occasion, with those eager for this art. And so now we shall take up the reckoning of the dimensions themselves, according to the Copernican (as we said) tenets, which will be displayed more readily in this manner from the figure set beside it.

Diagram. A schematic of the Tychonic world-system, viewed as a set of concentric circles centered on the Earth (A), with the Sun (B) at the center of the planetary circuits and Saturn's compounded epicyclic mechanism shown at the top. The figure is bounded by the starry orb (the outermost ring), which is drawn as a broad band densely stippled with engraved stars and labeled at its four cardinal points. A single vertical diameter runs through the whole figure from S at top to V at bottom, passing through the Saturnian epicycle assembly, the Sun, the Earth, and the inner orb.

- S (top, on the starry orb): cardinal point of the eighth/starry sphere
- V (bottom, on the starry orb): cardinal point of the eighth/starry sphere, opposite S
- X (left, on the starry orb): cardinal point of the eighth/starry sphere
- T (right, on the starry orb): cardinal point of the eighth/starry sphere
- A (center, marked with a small Sun-like disk inside the innermost circle): the Earth, center of the universe

- B (just above A, marked with an engraved Sun face): the Sun, center of the planetary circuits
- C (right of A, on the inner circle): point on the annual solar orb B C D E
- D (below A, on the inner circle): point on the annual solar orb
- E (left of A, on the inner circle): point on the annual solar orb
- H (below D, on the vertical diameter, on the Saturnian orb): lower cardinal point of the Saturnian circuit F G H I
- G (right, on the Saturnian orb): point on the Saturnian circuit
- I (left, on the Saturnian orb): point on the Saturnian circuit
- F (top, on the Saturnian orb, center of the larger small circle): upper point of the Saturnian circuit and center of the first small circle N K L M
- M (just above F): point on the first (larger) small circle N K L M
- N (left, on the larger small circle): point on the first small circle
- L (right, on the larger small circle): point on the first small circle
- K (center of the larger small circle / center of the smaller circle O P Q R): the star's center, carrier of the second small circle
- O (top, on the smaller circle): point on the second (smaller) small circle O P Q R
- P (right, on the smaller circle): point on the second small circle
- Q (bottom, on the smaller circle): point on the second small circle
- R (left, on the smaller circle): point on the second small circle

Since B F, the semidiameter of the primary orb of Saturn, taken as 10000 parts [partes], yields, according to Copernicus, B A as the semidiameter [of the annual orb], the annual orb of the Sun comes to 1090 of those same parts. It works out, therefore, that F K, the semidiameter of the larger small circle — by which the principal eccentricity is accounted for — is 854 parts, and K O, the semidiameter of the smaller small circle, is 285 parts, by which the other inequality of the equant is regulated. Or, if one prefers to reconcile these with respect to the annual orb of the Sun — in the same way that Copernicus himself also did in a certain little treatise on hypotheses framed by him, which the most distinguished Master Thaddeus Hagecius [Tadeáš Hájek], joined to me in long-standing friendship, once shared with me in manuscript at Regensburg, and which I afterward passed on to certain other mathematicians in Germany; the reason I

mention this is so that those into whose hands that writing may come may know from where it came. There, I say, in that same place, Copernicus compares the magnitudes of the orbs of the planets by reference to the annual orb of the Earth,

which we assign to the Sun, in such a way that he presupposes the semidiameter of this [annual orb] to be 25 parts. Working it out, then, in the case of Saturn the semidiameter of the principal orb E B comes to 230 parts 10 minutes of those same [units]; and the semidiameter of the first small circle F K is 19 parts 41 minutes. But that of the second is only 6 parts $\frac{3}{4}$ [6 $\frac{4}{3}$ as printed — see note]. For by hypothesis the semidiameter of the first is threefold larger than the semidiameter of the latter.

But indeed, in reducing all of this to the measure of the semidiameters of the Earth, and chiefly relying on that commensuration which he enumerates in his work on the revolutions — which seems to be the more exact, although this other one, of which we have just spoken, differs from it imperceptibly — what we are aiming at comes out in this way. Taking A B, the semidiameter of the solar circuit, as 1150 semidiameters of the Earth, as our limitation bears: B F will now be very nearly 10550, and F K 900, K O 300. If, therefore, we combine A B with B F, and add on top of that F K and K O, we shall make up the most remote distance of Saturn's revolution from the Earth: 12900 semidiameters of the Earth. And this is the ultimate interval within which Saturn's star carries out its gyrations with respect to the Earth.

Yet its body itself is never so highly elongated from here. For if the center of the smaller epicycle is set at K, at the apogee of the larger one, then Saturn's star is always at Q, that is, near the perigee of the smaller little circle. For this reason it will be removed from the Earth by the quantity of the diameter of that same little circle O Q — which is 600 — less than its apex requires at O. The supreme exaltation of Saturn's star, then, which can ever occur, from the center of the universe, will be 12300 semidiameters of the Earth. And this is why, in the preceding chapter, we presupposed that the New Star was elongated 12300 semidiameters from the Earth: raising it very close beside the maximum remotion of Saturn's star, and deliberately augmenting the Copernican measurement somewhat in these matters, so that the star might be presupposed to have stood around the limits of our supreme remotion of Saturn. There, too, we show that it is not altogether immune from all parallax, but that at so great a height, parallax to the amount of roughly a quarter of one minute would be admitted — even though it has by no means been possible to perceive any at all by instrumental observation. We did this for the following reason: so that, as far as could be done, we might demonstrate that this star was raised beyond the very greatest digression of Saturn elevated from the Earth — and therefore also beyond the orbs of all the other planets — and that it had chosen a seat for itself among the fixed stars. And let it suffice to have shown beforehand these things

concerning the supreme elongations of Saturn from the Earth. With this foundation laid, it will be plainer and more straightforward to ascend to the sphere of the fixed stars, which lies next above this one, and to measure out their visible bodies.

On the True Magnitudes of the Fixed Stars: the Author's Assessment

[De Affixarum Stellarum veris Magnitudinibus, Autoris censura]

Since I now intend to determine in advance the magnitudes of the fixed stars from their apparent diameter and their distance, together with the size of the New Star [New Star of 1572], I think it more fitting that the position of these stars be set a little beyond the topmost point of the smallest orbit. But because the apogee of that same smallest orbit is, by what was said earlier, distant 12,900 Earth-semidiameters [semid. Terrae], we can hardly bring the boundary of the eighth sphere of the fixed stars [Octavae Affixarum Sphaerae] closer to the Earth than a distance of about 13,000 Earth-semidiameters — so that some space (as is proper) may lie between these stars and Saturn's highest revolutions. And since, moreover, it is uncertain whether all the stars lie equally far from us in the same orb, and since it seems more probable that some are placed higher and others lower, I have therefore judged it more prudent if I add a further thousand Earth-semidiameters to the previous sum, so that on this reckoning a space large enough may be given within which the fixed stars may be arranged, some higher and some lower.

For these matters are not, after all, things that can be tracked down by an exact and refined measurement, nor is any very precise accuracy necessary in them. Who indeed would rightly fault us for having enlarged the boundaries of the eighth sphere by yet another thousand Earth-semidiameters, so that it is set at a distance from the Earth into the whole universe of about 14,000 semidiameters — that is, by a double thousands-of-seven, or by a single one, if we adopt the measure of seven thousand whole [Earth-]diameters? For even according to the Ptolemaic [Ptolemy] arrangement of the celestial orbs it would have to be raised a further 6,000 semidiameters higher. And if it pleased us to assent to the Copernican [Copernicus] speculation, concerning the annual motion of the Earth, there would still remain an immense vastness within Saturn and the eighth sphere before the annual motion of the Earth, considered in proportion to this, would entirely vanish as it ought. So much so that the interval which extends from the center of the universe up to the highest point of Saturn would be

contained more than seven hundred times over within the space between Saturn and the fixed stars — and that this space should be wholly empty and assigned to no use perceptible to the senses, which it is absurd to believe.

Therefore, taking it as settled that the fixed stars are removed from the Earth by 14,000 Earth-semidiameters, more or less, as we have just said, we shall now measure their true magnitudes, as accurately as can be done, in the following manner, according to those six orders into which they were divided by the ancients, and from their visible diameter.

The brighter stars, which they call of the **first magnitude** [Primae Magnitudinis], I have found by careful consideration to fill very nearly two minutes in their diameter, especially those that are of a middling sort. Therefore, if we take their distance from the Earth as 14,000 Earth-semidiameters, the circumference of the orbit

in which they lie will be 88,000 [Earth-semidiameters] (for these have the ratio of 7 to 22). Since this is presupposed to contain 360 degrees, two minutes correspond to 4 whole Earth-diameters [Terrae Diametri], and a little more — about $1/15$ — so that the ratio of their semidiameter to the Earth's semidiameter is as 52 to 13. Therefore, according to the reasoning set out above, it turns out that they are about 68 times larger than the Earth in their bulk — although the ancients reported that they exceed it more than a hundredfold. It is nevertheless likely that certain ones outstanding in visible size and in the prerogative of their light — surpassing the rest of the same order (such as Sirius [Canis maior] and Vega [Lyra]) — provided they are at an equal distance from the rest, are somewhat larger: so much so that they fall not far short of exceeding the Earth's mass a hundredfold. This will be the case if we take their apparent diameter as larger by about a quarter of one minute. So too those that appear smaller among the stars of the first rank, falling short of those other two minutes by a quarter of one minute, are reckoned to be not much larger — 45 times larger than the Earth.

The stars of the **second order** [Secundi Ordinis], among those which most stand out above the rest, I have observed to contain in their visible diameter about one and a half minutes [sesquialterum minutum]. Thus, if they are likewise presupposed to be equally distant from the Earth, their true diameter will comprise three Earth-diameters and $1/3$ more, so that the ratio of their semidiameter to the Earth's semidiameter is as 55 to 18. Therefore they exceed the Earth's mass by very nearly $28\frac{1}{2}$ times — although the ancients estimated them to be ninety times larger than the Earth.

The stars of the **third magnitude** [Tertiae Magnitudinis] I judge to fill in their visible diameter one minute and one, and a little something beyond — about $1\frac{1}{12}$ of a minute — provided one looks at the brighter among them. Therefore they contain, keeping the same distance, about $2\frac{1}{3}$ Earth-diameters, the ratio of their diameter being about as 20 to 9. From which they exceed the Earth's globe nearly 11 times. This the ancients thought to be 72-fold.

The stars of the **fourth magnitude** [Quartae Magnitudinis] I reckon to occupy $\frac{3}{4}$ of one minute. From which they subtend $1\frac{12}{30}$ Earth-diameters in the starry orb, so that the ratio of the diameters is about as 3 to 2 — nearly, in sesquialterate proportion. Hence the stars come out as one and a half times and a quarter larger than the Earth — though the ancients supposed them to exceed it fifty-four times over.

The stars of the **fifth order** [Quinti Ordinis] obtain, in my judgment, half a scruple [dimidium scrupulum], so that they are a little more than equal to one Earth-diameter, the proportion being as 50 to 49. Therefore they include the Earth's globularity $1\frac{1}{18}$ times — although otherwise, in the opinion of the ancients, they are estimated to be thirty-six times larger than this.

The stars of the **sixth quantity** [Sextae Quantitatis], which are the smallest among those that the astronomers have noted down, obtain a third part of one minute as to their appearance. Therefore the Earth is found to be somewhat larger than they are. For they do not subtend much beyond $\frac{2}{5}$ of its diameter, so that the ratio of their

diameter to the Earth's diameter is as 15 to 22. Therefore the Earth's globe is about three times larger than they are — so that, as it has been handed down from our predecessors, they exceed the terrestrial body in their quantity at least sixteen times over.

In very nearly this manner the fixed stars present themselves, both visible and in their true magnitudes, just as we have now reviewed them, insofar as they have been distributed by the ancients into definite classes. Everywhere, however, it must be noted that if any stars of the same designation are found to be a little larger or smaller, while in other respects they are mostly comprehended under the same order, one should add something to the magnitude assigned to them, or subtract something, according as they approach more nearly to the immediately preceding or following category. All of which are to be discerned only by a more probable estimation, and are not subject to an exquisite adjudication: so they have no need, in themselves, of any very precise knowledge.

If, according to the manner of al-Battānī [Albategnij] and al-Farghānī [Alfragani], these quantities were distributed in such a way that a sixth part of the globular size were consequently lost, the discrepancy from the position of the ancients would not turn out to be so great, especially in the smaller stars. For taking the stars of the first rank as about 68 times larger than the Earth, with this sixth part subtracted, the stars of the second order would become correspondingly larger — 57; the third 45; the fourth 34; the fifth 22; the sixth 11. But this commensuration is, in my judgment, unsuitable, and contrived at pleasure.

It must moreover be noted here too — as we hinted before — that it may be the case that the several fixed stars are not removed from the Earth at an equal interval, but that some stand nearer and others, by contrast, farther off. If this is so, the stars that are farther off will appear smaller than those that are nearer, even though in the heaven itself they possess, in themselves, an equal quantity, or about so. On this reasoning, the stars of the second status are reckoned not to be smaller than those counted in the first order; and the third are to be equated with the second (and so for the rest, according as more or less is fitting). Nevertheless, in my judgment, one ought not to admit too great a vastness here for the boundaries of the eighth sphere. For it cannot be that the smallest stars, which are reckoned of the sixth order, are removed from the Earth by so great an interval as to render them equal to those which are of the first and chief brilliance. For this interval would turn out to be excessively large; so much so that it would contain more than 155,000 Earth-semidiameters. And so they would have to be raised eleven times higher than we have assumed their loftiness to be. And thus that space allotted to the eighth orb would embrace, eleven times over, that interval which extends from the Earth up to the presupposed boundaries of that same orb — which surely exceeds all measure and credibility. It is therefore more probable that certain stars are in truth larger in themselves, and that the manifold variety in which Nature delights is to be found in them. But now it will be the right moment to measure the New Star itself.

On the True Magnitude of the New Star.

[De Stellae Novae vera Magnitudine]

Since two things are required for duly accomplishing this task — namely the apparent diameter of the star and its distance from our sight, just as in the case of the other heavenly bodies these data had to be ready at hand — we shall therefore first make these requisites known, with all the accuracy that can be managed.

Although, by no instrument, while it was being observed — and especially when it was in its chief vigor — were we divinely permitted to take from heaven the visible diameter of the star (a thing that, of itself, on account of the excessive scintillation of its rays, was subject to no slight difficulty): nevertheless, by a comparison made with the rest of the heavenly bodies, and especially with the stars of Jupiter and Venus, with which at the beginning, when it was at its fullest brilliance, it very nearly matched its conspicuous quantity, its apparent diameter can be determined sufficiently for this business.

We indicated, indeed, in Chapter 3 [Cap. 3] that its visible magnitude somewhat exceeded the radiance of Jupiter — even then, when Jupiter was nearer the Earth — and that it approached more closely the brightness of Venus, especially when Venus, being near the Earth, shines forth with a fuller face. This was clear, not obscurely, not only to us but also to very many others who attentively gazed at this star from the beginning. And so it came about, in some measure, that around the first beginnings of its appearance it could at times even be discerned distinctly in the daytime, when the air was clear. Therefore, since from what was recounted above it is established that the star of Jupiter, when it is at about its middling elongation from the Earth, fills $2\frac{3}{4}$ minutes — it was somewhat larger at that time, when Jupiter in its retrograde course was near the perigee of the eccentric (as they commonly say), or of the first epicycle, drawing nearer to us according to our own reasoning, so that at the least it appears, for the same reason, larger by a quarter of one minute, and thus would subtend three whole minutes. The star of Venus, on the other hand, although at its middling distance from the Earth it scarcely contains beyond $3\frac{1}{4}$ minutes in apparent diameter: nevertheless, when it is carried near the lower part of its orb, and has departed somewhat from the Sun, it is seen to fill four minutes, if not indeed somewhat more. For we too have sometimes, when its visible diameter approached very near the Earth and it was seen larger than usual, found it by careful sighting to reach very nearly five minutes. But in this place we shall take that diameter of Venus which it presents for the most part at morning and evening, when it has strayed somewhat from the Sun — namely four minutes. And since this New Star, in its visible quantity, was not made altogether equal to the star of Venus, but represented it more closely than Jupiter (as has been said), it will be appropriate to set its visible diameter as a little less than 4 minutes and more than 3 minutes. Therefore this will duly

by weighing and delimiting it accordingly, we shall scarcely stray from the just standard if we take the visible diameter of this star to be $3\frac{1}{2}$ minutes, as though intermediate between the stars of Jupiter and Venus — indeed, we shall judge

that it must rather have rivaled Venus, owing to the rays vibrating from it on every side. This, then, was the visible magnitude of the star at its very beginning, when it shone with its greatest splendor and force, worked out as accurately as can be done. Yet I do not doubt that some in the future will hold that this estimate was too narrowly restricted by us; for there are indeed some who suppose, quite groundlessly, that the stars of Jupiter and Venus, when they approach the Earth, subtend 7 or 8 minutes in their visible diameter.

We shall therefore establish, and take as a settled value, that the visible diameter of the New Star at the time of its first appearance — in the month of November, that is — was (as has been said) $3\frac{1}{2}$ minutes, and we shall place it at the same distance from the Earth that we earlier assigned to the fixed stars, namely 14,000 semidiameters of the Earth. (It could scarcely have been nearer, since even at this distance it would have admitted some parallax, slight though imperceptible to instruments.) Accordingly, from the reasoning set out above, the diameter of this star came to $7\frac{1}{8}$ diameters of the Earth. And on that account its bulk exceeded that of the Earth by $361\frac{1}{2}$ times. But so as not to seem to scrutinize these matters too scrupulously, it will be enough if we hold that this star was 360 times larger than the Earth. Even this magnitude may perhaps strike some as excessive; yet when each point is weighed individually, scarcely a smaller one can be allowed. Indeed, if these same figures were assessed in the same manner under the Ptolemaic hypotheses — by which the Eighth Sphere is removed about twenty thousand times the distance from the Earth — the star would turn out to be more than a thousand times larger than the Earth, which would be excessive. What is more, this star even exceeded the Sun itself in size by $2\frac{2}{3}$, as the ratio of the diameters with respect to the Earth requires. It is therefore quite clear how incredible...

incredible the magnitude was with which this star, of which we are treating, was endowed; and how great a marvel it was that so vast a frame — one which not only surpassed the Earth so many times over, but indeed was greater than all the other luminous bodies of the ethereal world, the Sun itself included — should have newly shone forth from on high in our own age. And from this, even from its magnitude alone, fair and candid judges will readily decide that we have not spent so much labor in vain in describing it accurately.

But just as this star diminished successively in its visible diameter after its first beginnings, so too it truly lessened, little by little, the very actual size it possessed in the heavens, until it was at last wholly dissolved. The things, then, that have just been said about its true magnitude refer chiefly to the month of November,

when it shone most brightly. For in the following December, when it rivaled the star of Jupiter, it can scarcely have been more than two hundred times larger than the Earth. In January of the following year, 1573, having grown still somewhat more attenuated, it held a magnitude more or less a hundred times greater than the Earth. But in February and March, when it was seen equal to stars of the First Magnitude, it expressed roughly their bulk, and was then about seventy times larger than the Earth. So too in April and May, matching stars of the Second Magnitude, it exceeded the Earth's mass nineteen times over. Finally, in summer, when it reported the size of fixed stars of the Third Quantity, it stood about eleven times greater than the Earth. In autumn, however, presenting stars of the Fourth Order, it exceeded the globe of the Earth four and a half times. At the very end of that same year 1573, and at the beginning of the following...

following year 1574, when it was likened to stars of the Fifth Class, it was very nearly equal to the Earth itself. About February, moreover, when it appeared so faint that it could scarcely be compared with stars of the Sixth Magnitude, it proved smaller than the Earth itself — so much so that the Earth surpassed it threefold. From that time on, growing more and more attenuated, it lost its visible magnitude little by little together with its true one, so that when the spring season was soon at hand, it both ceased to be visible and soon ceased to exist. For even if it perhaps lingered somewhat longer in the heavens than it lay open to sight — inasmuch as, on account of the thinness of its body and its excessive distance, it could no longer be observed by us — nevertheless, since it is impossible to fix any certain measure for things that do not fall within the senses, it would be superfluous to proceed any further in this commensuration.

By no means, therefore, do I think it should be admitted that this same star kept perpetually the one magnitude, and that it merely altered, by its withdrawal from our eye alone, and dwindled gradually by ascending ever higher — as some, taking their occasion from Seneca (as I suppose), have groundlessly maintained. For this star was in reality a certain new body, formed in one and the same time into the magnitude which it first possessed, and remaining always in the same place until it utterly vanished. For a rectilinear ascent and descent — unless it be compounded out of circular motions (and even so, scarcely) — does not belong to the heavenly bodies, as we have also argued earlier. And to what height, I ask, must this star have been raised, before it vanished entirely through mere elongation from our sight, while retaining its original magnitude? Certainly it would have to ascend at a minimum 300,000 semidiameters of the Earth...

300,000 semidiameters of the Earth higher from the position it held at the start, before it would be beheld in the likeness of a star of the Sixth magnitude — that is, more than twenty times beyond the assumed semidiameter of the Eighth Sphere; and still much higher, if it were to escape the sight of the eyes altogether. It is indeed certain that every visible thing can be set at such a distance from us that it cannot be apprehended by the senses of the eyes. Nevertheless, on that account it will not be permitted to wander too freely in disposing the bodies of the sensible world — as Copernicus seems to have erred in respect of the immense distance which he allowed for the fixed stars. For one ought to preserve a certain measure and a fitting proportion in these matters, lest the affair tumble into infinity; and the due symmetry of created and visible things, in respect of magnitude and distance, ought to be admitted — which it is surely right to preserve, since God, the Author of the universe, loves a fitting order, not confusion and disarray [ataxian].

And concerning the magnitude of this star — and the comparison of it not only with the Earth, but with the other bodies of heaven as well — let it suffice to have given this brief indication. The learned will easily work out for themselves the remaining points, should any happen to be lacking or to have been less particularly elucidated; for it is not for the ignorant and those little practiced in this art that we write these things.

Now, then, that the Second Part of the Book is complete, embracing our reasonings concerning this star, it will at last be opportune for us to turn to the Third — that we may at the same time look into the opinions of others.

PARS

PART THREE

Encompassing the observations and opinions of others concerning this star — as many as it was possible to obtain — and inquiring whether or not they agree with the actual appearances, by comparison both among themselves and with our own findings.

*

CAPVT OCTAVVM [Chapter Eight]

On the considerations and opinions of those by whom this star — entirely free of parallax, above the revolutions of the planets — is rightly attributed, in agreement with us, to the highest sphere of the fixed stars.

The conclusions we demonstrated in the five immediately preceding chapters, drawn from our own observations on the mathematical examination of this star, are of such a kind that no one who understands these matters can shake them on any just grounds. For that reason they stand in no need of any other person's endorsement, nor of corroborating observations made elsewhere, nor of being established by inferences deduced from such. Neither do they need the support of those who have attempted to bring forward contrary views — who have tried to fasten this star to the spheres of the planets, or even (as some have done) to reduce it altogether to something elemental, and who run into contradictions.

And yet, when some matter has at last been thoroughly discussed and confirmed in every way, it should be believed — even though those things that can be set forth about it demonstratively, from sure indications [Tecmiriis = Greek τεκμήρια, "proofs, evidences"], have not all been brought fully into the open. Still more should it be believed when other points that agree converge as corroborating it, are accepted as consistent with it, and when the objections raised on the contrary side, as being out of harmony with the truth and incongruous with it, are removed and dissolved — so that the naked truth, established on its own genuine supports and propped up by its own strength, once the extraneous and discordant elements are set aside, may stand inviolate and unconquered.

For this reason I think it not out of place if I now call to the anvil of truth the observations and opinions of others as well — as many as I have been able to lay hold of — concerning this star, and show to those eager for these matters how far they agree, or do not, both with this star, with our own observations, and also among themselves.

First, then, I will consider in this chapter the views of those who, on the basis of sound observations, raised this star above the spheres of the planets, and whose views accord most closely with my own conclusions regarding the imperceptibility of its parallax.

As for the others, of varied persuasions — those who associate it indeed with the celestial world, but with the spheres of the planets; and likewise those who tried to make it altogether sublunary and a participant in the elemental region; or who put forward some other absurd opinion about it — I shall examine their views against the measuring-rod of truth afterward, in the two chapters that follow.

Beginning, therefore, with the most illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel], among those who observed in agreement with us, I shall first weigh the findings of His Highness before all the rest.

ILLVSTRISSIMVS PRINCEPS VVILHELMVS HASSIAE LANDTGRAVIVS [The Most Illustrious Prince Wilhelm, Landgrave of Hesse]

Among those who in our age have devoted their minds to investigating the appearances of the heavenly bodies — who are, however, very few — no one in Germany or elsewhere, so far as I know, has been equipped with more solid and more skilfully wrought instruments than the most illustrious Prince Wilhelm, Landgrave of Hesse. He himself excels in skill at observing as well. (For he does not merely maintain others assigned to this office; His Highness himself does not disdain to keep watch diligently from time to time at his leisure.) It is therefore fitting that he should be set before others and deservedly hold the first and chief place — not only on account of his lineage and rank, but also for the excellence of this distinguished knowledge and pursuit. For the study of astronomy owes a great deal to this illustrious Prince, especially as regards the practice of observation, so far as it concerns the careful recording and restoration of the fixed stars; in which he has expended long-sustained and accurate labor — so that on this account too he deserves to be celebrated by later posterity.

But although at that time, when this star blazed forth from the heavens, he was not yet using instruments so exquisite and elaborated to such perfection — these being the ones he had constructed in the years immediately following, on the suggestion of a certain outstanding mathematician, Paul Wittich [Paul Wittich], who saw our own instruments here — nevertheless even those instruments, such as they were, which he then had at hand, left the little machines of other astronomers far behind. (For in those older ones the subtlety of the transversal division was not yet employed, nor were the sightings made through slits parallel to the forward pinnacidium [pinnacidio = sighting-vane], but only through apertures in the too-old-fashioned manner, with unsteady collimations.) They

were superior all the same, in that they were rather correctly elaborated in their fine symmetry, by reason of the solidity of the brass material and of the workmanship and construction, and for other reasons as well.

The said illustrious Prince, then, kindly shared with me some of his own observations made on this star. I shall review them here in the order in which they were set down in the papers sent to me, and afterward I shall explain what can be derived and confirmed from them.

Observations transmitted to me by the most illustrious Prince, as they were made at Kassel in Hesse.

In the Year of the Saving Birth 1572, on 3 December, at the prompting of the Elector of Saxony, I first saw and observed the New Star, greater and brighter than Venus itself, in the asterism of Cassiopeia. The Sun at the time of observation stood at 21 degrees 30 minutes of Sagittarius [♐], as was determined from its meridian observations. The observations made on that day stand as follows.

Die 3 Decembris [3 December]

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
7 — 52	144 — 0	75 — 42
8 — 16	138 — 0	71 — 20
8 — 34	135 — 0	71 — 25
9 — 16	131 — 30	66 — 40

Die 4 Decembris [4 December]

The Sun at the time of observation at 26 parts 31 minutes of Sagittarius [♐].

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
8 — 11	138 — 0	73 — 20
8 — 16½	137 — 0	72 — 45

Die 10 Decembris [10 December]

The Sun at the time of observation at 28 parts 40 minutes of Sagittarius [♐].

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
7 — 11¼	147 — 0	76 — 32
7 — 14	146 — 0	76 — 19

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
7 — 20½	144 — 0	75 — 42

Die 26 Decembris [26 December]

Place of the Sun [☉] at the time of observation 16 degrees 20 minutes of Capricorn [♐].

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
4 — 21	161 — 0	78 — 43
4 — 26½	164 — 0	79 — 0
4 — 38	171 — 0	79 — 22
4 — 51	180 — 0	79 — 30

Die 29 Decembris [29 December]

The lower altitude of the New Star on the northern meridian: 23 degrees 2½ minutes. [G. 23. M. 2½]

ANNO 1573. 2 Ianuarij [Year 1573, 2 January]

The lower altitude of the New Star on the meridian: 23 degrees 3 minutes. [G. 23. M. 3]

Die 11 Ianuarij [11 January]

Place of the Sun [☉] at the time of observation 1 degree 50 minutes of Aquarius [♒].

Tempus (H. — M.)	Azimuth Occid: (G. — M.)	Altitudo (G. — M.)
4 — 35	152 — 30	77 — 37
4 — 36	152 — 0	77 — 33
4 — 37½	151 — 30	77 — 27

26 Februarij [26 February]

Place of the Sun [☉] at the time of observation 18 degrees 0 minutes of Pisces [♓].

Tempus (H. — M.)	Azimuth (P. — /.)	Altitudo (P. — /.)
7 — 58	145 — 30	36 — 45
8 — 3	146 — 0	36 — 20

11 Martij [11 March]

Place of the Sun [☉] at the time of observation 0 degrees 55 minutes of Aries [♈].

Tempus (H. — M.)	Azimuth (P. — /.)	Altitudo (P. — /.)
7 — 50	149 — 30	33 — 30
7 — 53½	150 — 0	33 — 10

14 Martij [14 March]

Place of the Sun [☉] at the time of observation 3 degrees 50 minutes of Aries [♈].

Tempus (H. — M.)	Azimuth (P. — /.)	Altitudo (P. — /.)
8 — 2	152 — 0	31 — 43

Thereafter, since I could detect no motion in this star, I observed it no further.

[Margin: In the margin, where these observations were recorded, the following was noted. "Here an elevation of the pole of 51 degrees 16 minutes was assumed, as was also found from observations of the stars of Ursa Major at that time — owing, I think, to a fault of the instrument."]

These were the Landgrave's observations concerning this New Star, shared with me. From them, moreover — since at the very head of the observation he records that around the beginning of December this newly arisen star was greater and brighter than Venus — there is no great disagreement with the other accounts that we set down in general in the third chapter regarding its visible magnitude and form. For as to its appearing larger, I judge that he is not speaking of that aspect of Venus by which, as it approaches the Earth, it shines forth more brilliantly, but only of its ordinary and common appearance. He does not, however, note here the variation of magnitude that the star afterward underwent; but in the letters that we shall bring forward in the following chapter he makes some mention of this diversity.

Now let us examine what can be built up mathematically upon these observations of the most illustrious Prince, and what can be deduced from them.

We shall undertake first the measurement of the parallax — if any arises from these data, since in this lies the principal hinge of the whole matter — in the following manner.

He determined the greatest altitude of this star at Kassel, when it was on the meridian above the pole, by his instruments, as 79 parts 30 minutes, as is clear

from the observation made on 26 December. The least elevation of the same star above the horizon he recorded on 29 December as 23 parts 23 minutes $2\frac{1}{2}$ [recte: 23 parts $2\frac{1}{2}$ minutes],

namely, that on 2 January of the following year, [15]73, it would yield the same [pole altitude] greater by half a minute — though this is of no great consequence. To these observations we shall apply the same pole altitude that was at that time taken from the circumpolar stars with the same instrument, just as was reported there: $51^{\circ} 16'$. For although they afterward noticed that it was actually two, or rather three, minutes greater, nevertheless — because it was derived from stars revolving about the pole and not setting, which are likewise endowed with this same favorable condition — we judge it more prudent to apply to this star as well the very pole altitude that was then found, even though it falls short by a few minutes. For in this way the same standard will be applied to it as to the fixed stars, and everything will square more correctly with the rest; and any defect in the instrument, if there was one, since it works its way in equally at both points, will be corrected for the very thing we are aiming at all the more aptly.

When, therefore, from the greatest altitude of the star noted above, $79^{\circ} 30'$, the said pole altitude of $51^{\circ} 16'$ is subtracted, there results its distance from the pole, which it had when nearest this point of approach to the zenith: $28^{\circ} 14'$. But when it was carried down toward the horizon, the least altitude then taken, $23^{\circ} 2\frac{1}{2}'$, being subtracted from the pole's elevation, yields the same star's lower remove: $28^{\circ} 13\frac{1}{2}'$. This falls short, by barely half a minute, of the value reached when it was above the pole toward the zenith — a deficiency scarcely perceptible. Yet had it been subject to any appreciable parallax, this star's remove from the pole would have been greater below the pole than above it. Therefore, since no discrepancy is found — indeed, since the matter rather turns out half a minute in the contrary direction — it is sufficiently clear from these very observations of the Landgrave's party that no parallax whatever can be derived, so much so that his Lordship's observations agree very closely in supporting our own in this respect.

So too, if from the star's greatest and least altitudes — whose difference is $56^{\circ} 27\frac{1}{2}'$ — we add half of this to the least elevation, or subtract it from the greatest, there results a pole altitude of $51^{\circ} 16\frac{2}{3}'$. This agrees with the value then deduced from the circumpolar stars, so much so that it even exceeds it by at least a quarter of a minute — which proves, rather than disproves, that there was no parallax at all. For had there been one, the pole's elevation gathered from this would then have come out not greater but smaller.

Since, therefore, this star revolved about the pole in an altogether similar manner, showing the same elevation of itself everywhere, it necessarily follows that it was not exempt from the laws of the fixed stars, and so it chose for itself the seats nearest these and likewise free of all parallax.

For if this star had been so near to the earth that it expressed any perceptible trace of diversity of aspect, the aforesaid values above and below the pole would certainly not have agreed so neatly into one. If anyone resolves into numbers the demonstrations we applied to a similar problem in Chapter 6, he will find that at the greatest altitude, $74\frac{1}{2}^{\circ}$, it would have been at the confines of the lunar sphere with a parallax of $12'$ — the solar parallax being $0' 31''$. But at the nearest altitude this would have held...

in relation to the Moon, $1^{\circ} 0'$, in relation to the Sun, $0^{\circ} 2\frac{3}{4}'$. From these it plainly follows that, had this star been below the concavity of the lunar sphere, then when it approached the horizon at its nearest altitude it must have stood farther from the pole — by a whole degree and 12 minutes — than above it. In relation to the Sun's highest elongation, the difference would still have been three minutes, perceptible enough. In relation to Saturn's greatest, although the diversity would be tiny and imperceptible, nevertheless that it is not even to be placed within these limits is sufficiently confirmed by the other evidence we set forth earlier.

And these results, as regards the situation of the phenomenon — that it must be placed in the highest ether — are not merely admirably supported by our assertions; they also yield very nearly the same declination as we found above. For the lower distance from the pole, which was $28^{\circ} 13\frac{1}{2}'$, gives a declination whose complement to a quadrant is $61^{\circ} 46\frac{1}{2}'$, falling short of ours by only half a minute. In the upper situation, when the distance from the pole was found to be $28^{\circ} 14'$, the same declination comes out as $61^{\circ} 46'$, smaller by only a single minute still. But this tiny difference, of half a minute or a whole minute, is easily excused by the instruments — not yet so perfected as those the illustrious Landgrave was then using — though the matter is in itself of no great moment. That something quite trifling is to be desired in these observations is sufficiently suggested by the observations made at Augsburg [Augustae Vindelicorum] with the great quadrant, which still gave a slightly larger declination for the star, $61^{\circ} 48\frac{1}{2}'$ — to which our own newly devised declination comes closer, so that it is, as it were, intermediate between the Landgrave's and the Augsburg determination, the discrepancy in each individual case being exceedingly small.

Therefore, since it is now abundantly clear from the said observations of the most illustrious Prince the Landgrave that this star admitted no parallax whatever,

and that its apparent and true place coincided altogether into one — just as happens among the fixed stars — we do not wish to dwell any longer on belaboring these points. For although the same thing could be confirmed in several other ways from the recorded observations, using the given azimuths and altitudes together with the elapsed time, nevertheless, since exploration by the position of the meridian is both simpler and safer in both respects, and since whatever is gathered apart from this — from azimuths and altitudes — is entangled in many complications, and, on account of the requirement of an extremely precise knowledge of the intervening time (which is granted only with the greatest difficulty), is more prone to error: to what end labor to seek a knot in a bulrush, and confuse by intricate handling matters that stand firm by plain and ready truth?

Now, then, we shall investigate, from these observations of the Landgrave's, the place that the star occupied with respect to the equator and then also to the ecliptic, and we shall compare it with our own. We shall do this for each of the several days on which these observations were attended to, so that, when the comparison of all of them has been made, the aim we seek may be attained as nearly as possible.

There follows the investigation of the right ascension of the New Star, from the data noted earlier, but with the place of the Sun taken from our Tables for its motion.

By the figure set out here, let DCF be conceived as the meridian; DF the horizon, whose pole is at C; LG the equator, with its own proper pole at B. Let there descend from these poles to their respective quadrant-circles CH and BK, in such a way that the arc HF measures the horizon's azimuth of the star, reckoned from the meridian toward the west; HA, moreover, measures its altitude above the horizon; KA the declination; and KG the equatorial distance from the meridian — the two quantities which come last to be investigated.

Diagram. A sphere (drawn as a circle) representing the celestial sphere with the principal circles of the observation triangle. The meridian, horizon, and equator are drawn as great circles intersecting within the disk, with several lettered points marking poles, intersections, and the star's position.

- B (upper left, near top): pole of the equator
- C (top): pole of the horizon (zenith)
- A (interior, upper middle): position of the New Star

- G (right): point on the equator
- D (left): point on the meridian/horizon
- K (interior, right of center): foot of the declination arc on the equator
- F (right edge): point on the meridian/horizon
- H (lower interior, left of center): foot of the azimuth/altitude arc on the horizon
- I (lower interior, center): intersection point
- E (lower left): point on the horizon

Taking, then, the first observation, made on 3 December at 7h 52m, when the western azimuth was $144^{\circ} 0'$ and the altitude $75^{\circ} 42'$: in this very construction there is to be considered a single triangle, BAC. The side BC, $35^{\circ} 44'$, represents the complement of the pole's elevation. The side AC, $14^{\circ} 18'$, the complement of the star's altitude. The angle ACB, $36^{\circ} 0'$ — for it is the complement of the found azimuth from a semicircle. Hence, from the two given sides containing a known angle, the side BA will not conceal itself: $28^{\circ} 15'$. This indicates the complement of the New Star's declination, and so the declination itself will be evident.

Furthermore, from the three now-known sides of the same triangle, the angle ABC will come out plainly as $12^{\circ} 52'$, which measures the star's equatorial distance from the meridian. Hence its right ascension will be easily hunted down in the following manner.

The place of the Sun for the predetermined time, taken from our Ephemeris in Chapter One, is assigned at $\times 21^{\circ} 59'$, whose right ascension, also from our Canon in the same chapter, is $261^{\circ} 17'$. For the 7h 52m elapsed since the meridian, $118^{\circ} 0'$ must be added, so that the right ascension of the mid-heaven at that time is $19^{\circ} 17'$. If from this is subtracted the New Star's distance from the meridian found earlier, $17^{\circ} 52'$, the star's sought right ascension is elicited: $1^{\circ} 25'$. The declination, derived from the complement found earlier, comes out as $61^{\circ} 45'$.

But so as not to repeat this exposition tediously several times over, it is convenient to comprehend summarily the values that result, by this same procedure, for the individual times of the observations — yet in all of these the process of demonstration and collection just indicated must be understood. I shall carry everything through until the sought right ascension of the New Star is evident. Nor shall I assign the declination separately for each, since it is easily seen from the complement of the side BA.

8h 16m. Azimuth 138° 0' west; Altitude 73° 20'.

		P .	M.		P.	/.
Latus	B C	3	44	Locus ☉	22	0½ ↗
		8				
Latus	A C	1	40	Ascens. R. ☉	26	18
		6			1	
Angulus	A C B	4	0	Pro Horis elapsis	12	0
		2			4	
Hinc Latus	B A	2	16⅔	Asc. R. medij Cæli	25	18
		8				
Angulus	A B C	2	53½	Asc. R. Nouæ	1	24½
		3				

8h 34m. Azimuth 135° 0' west; Altitude 71° 25'.

		P .	M.		P.	/.
Latus	B C	3	44	Locus ☉	22	1¼ ↗
		8				
Latus	A C	1	35	Ascens. Recta ☉	26	18½
		8			1	
Angulus	A C B	4	0	Pro Horis elapsis	12	30
		5			8	
Hinc Latus	B A	2	18⅔	Asc. R. m. c.	29	48½
		8				
Angulus	A B C	2	23	Ascens. R. Nouæ	1	25½
		8				

9h 16m. Azimuth 131° 30' west; Altitude 66° 40'.

		P .	M.		P.	/.
Latus	B C	3	44	Locus ☉	22	3 ↗
		8				
Latus	A C	2	20	Asc. Recta ☉	26	20¼
		3			1	

		P .	M.		P.	/.
Angulus	A C B	4 8	30	Pro Horis elapsis	13 9	0
Hinc Latus	B A	2 8	18	Asc. Rect. m. c.	40	20¼
Angulus	A B C	3 8	44½	Asc. Recta Nouæ	1	36

THE FOURTH DAY.

8h 11m PM. Azimuth 138° 0' west; Altitude 73° 20'.

		P .	M.		P.	/.
Latus	B C	3 8	44	Locus ☉	23	1½ ↗
Latus	A C	1 6	40	Ascens. R. ☉	26 2	25
Angulus	A C B	4 2	0	Pro Horis elapsis	12 2	45
Hinc Latus	B A	2 8	16⅔	Asc. R. Med. c.	25	53
Angulus	A B C	2 3	53	Asc. R. Nouæ	1	17

8h 16½m. Azimuth 130° 0' west; Altitude 72° 45'.

		P .	M.		P.	/.
Latus	B C	3 8	44	Locus ☉	23	1¾ ↗
Latus	A C	1 7	15	Ascens. Rect. ☉	26 2	25¼
Angulus	A C B	4 3	0	Pro Horis elapsis	12 4	7½
Hinc Latus	B A	2 8	16½	Asc. R. m. c.	26	32¾

		P			P.	/.
		.	M.			
Angulus	A B C	2	15½	Asc. Rect. Nouæ	1	17¼
		5				

On the Tenth of December.

At 7h 11¼m. Azimuth from the west [P.] 147°, 0'. Altitude 76°, 32'.

		P			P	
		.	M.		.	M.
Side [Latus]	B	3	44	Place of the Sun [Locus ☉]	2	6¾ ↗
	C	8			9	
Side [Latus]	A	1	28	Right ascension of the Sun	2	2
	C	3		[Ascens. r. ☉]	6	
					9	
Angle [Angulus]	A	3	0	For the elapsed hours [Pro	1	52½
	C	3		Horis elapsis]	0	
	B				7	
Hence the side [Hinc	B	2	15	Right ascension of the	1	4½
Latus]	A	8	½	midheaven [Asc. r. medij	7	
				Caeli]		
Angle [Angulus]	A	1	32	Right ascension of the New	1	32
	B	5	½	Star [Asc. r. Novae]		
	C					

At 7h 14m. Azimuth 146°, 0'. Altitude 76°, 49'.

		P			P.	'.
		.	M.			
Side	B	3	44	Place of the Sun	2	6½ ↗
	C	8			9	
Side	A	1	41	Right ascension of the Sun	2	2
	C	3		[Ascens. Recta ☉]	6	
					9	
Angle	A	3	0	For the elapsed hours	1	30
	C	4			0	
	B				8	

		P · M.		P. '.
Hence the side	B	2 17	Right ascension of the	1 32
	A	8	midheaven [Asc. r. m.c.]	7
Angle	A	1 12 $\frac{2}{3}$	Right ascension of the New	1 19 $\frac{1}{2}$
	B	6	Star [Ascens. r. Novae]	
	C			

At 7h 20 $\frac{1}{2}$ m. Azimuth 144°, 0'. Altitude 75°, 42'.

		P · M.		P. '.
Side	B	3 44	Place of the Sun	2 7 $\frac{1}{6}$ ♂
	C	8		9
Side	A	1 18	Right ascension of the Sun	2 2 $\frac{1}{3}$
	C	4	[Asc. Recta ☉]	6
				9
Angle	A	3 0	For the elapsed hours	1 7 $\frac{1}{2}$
	C	6		1
	B			0
Hence the side	B	2 14 $\frac{4}{7}$	Right ascension of the	1 9 $\frac{5}{6}$
	A	8	midheaven [Asc. Rect. m.c.]	9
Angle	A	1 52	Right ascension of the New	1 17 $\frac{5}{6}$
	B	7	Star [Asc. Recta Novae]	
	C			

On the Twenty-Sixth of December.

At 4h 21m. Azimuth 161°, 0'. Altitude 78°, 43'.

		P · M.		P. '.
Side	B	3 44	Place of the Sun	1 20 $\frac{5}{6}$ ♀
	C	8		5
Side	A	1 17	Right ascension of the Sun	2 40
	C	1	[Ascens. r. ☉]	8
				6
Angle	A	1 0	For the elapsed hours	6 15

		P			P.	'.
		.	M.			
	C	9			5	
	B					
Hence the side	B	2	16	Right ascension of the	3	55
	A	8		midheaven [Asc. r. Med. c.]	5	
					1	
Angle	A	7	43	Right ascension of the New	3	38½
	B		½	Star [Asc. r. Novae]	5	
	C				9	

At 4h 26½m. Azimuth 164°, 0'. Eastern. Altitude 79°, 0'.

		P	M		P.	'.
		.	.			
Side	B	3	4	Place of the Sun	15	21 ⅞
	C	8	4			
Side	A	1	0	Right ascension of the Sun	26	40⅓
	C	1		[Ascens. Rect. ☉]	8	
Angle	A	1	0	For the elapsed hours	66	37½
	C	6				
	B					
Hence the side	B	2	1	Right ascension of the midheaven	35	17⅝
	A	8	8	[Asc. r. m.c.]	3	
Angle	A	6	2	Right ascension of the New Star	35	41
	B		3	[Asc. Rect. Novae]	9	
	C					

At 4h 38m. Azimuth from the west [P.] 171°, 0'. Altitude 79°, 22'.

		P			P.	M.
		.	M.			
Side	B	3	44	Place of the Sun	1	21½ ⅞
	C	8			5	
Side	A	1	38	Right ascension of the Sun	2	40⅔
	C	0		[Ascens. r. ☉]	8	
					6	
Angle	A	9	0	For the elapsed hours	6	30

		P				P.	M.
		.	M.				
	C					9	
	B						
Hence the side	B	2	15 $\frac{2}{3}$	Right ascension of the		3	10 $\frac{3}{4}$
	A	8		midheaven [Asc. r. medij Caeli]		5	
						6	
Angle	A	3	22	Right ascension of the New		2	32 $\frac{3}{4}$
	B			Star [Asc. r. Novae]		5	
	C					9	

At 4h 51m the New Star was on the meridian [fuit Nova Stella in Meridiano].
Altitude [P.] 79°, 30'.

	P.	'.
Place of the Sun [Locus ☉]	15	22 $\frac{1}{6}$ ♌
Right ascension of the Sun [Ascens. Recta ☉]	286	41 $\frac{1}{4}$
For the elapsed hours [Pro Horis elapsis]	72	45
Right ascension of the New Star [Ascens. r. Novae]	359	26 $\frac{1}{4}$
Declination [Declinatio]	61	46

IN THE YEAR 1573.

On the Eleventh of January.

At 4h 35m. Azimuth 152°, 30'. Altitude 77°, 37'.

	P				P.	'.
	.	M.				
Side	B	3	44	Place of the Sun	1	40 $\frac{5}{6}$ ♍
	C	8				
Side	A	1	23	Right ascension of the Sun	3	56 $\frac{2}{3}$
	C	2		[Asc. Recta ☉]	0	
					3	
Angle	A	2	30	For the elapsed hours	6	45
	C	7			6	
	B					
Hence the side	B	2	14 $\frac{2}{3}$	Right ascension of the	1	41 $\frac{2}{3}$

		P · M.		P. '.
	A	8	midheaven [Asc. Rect. m.c.]	2
Angle	A	1 5½	Right ascension of the New	0 36
	B	2	Star [Asc. Recta Novae]	
	C			

At 4h 36m. Azimuth 152°, 0'. Altitude 77°, 33'.

		P · M.		P. '.
Side	B	3 44	Place of the Sun	1 41 ≈
	C	8		
Side	A	1 27	Right ascension of the Sun	30 56⅔
	C	2	[Ascens. r. ☉]	3
Angle	A	2 0	For the elapsed hours	69 0
	C	8		
	B			
Hence the side	B	2 15½	Right ascension of the	12 56⅔
	A	8	midheaven [Asc. r. Med. c.]	
Angle	A	1 20⅔	Right ascension of the New Star	0 36
	B	2	[Asc. r. Novae]	
	C			

At 4h 37½m. Azimuth 151°, 0'. Eastern. Altitude 77°, 27'.

		P · M.		P. '.
Side	B	3 44	Place of the Sun	1 41 ≈
	C	8		
Side	A	1 33	Right ascension of the Sun	30 57
	C	2	[Ascens. Rect. ☉]	3
Angle	A	2 30	For the elapsed hours	69 22¼
	C	8		
	B			
Hence the side	B	2 15	Right ascension of the	13 18⅓
	A	8	midheaven [Asc. r. m.c.]	
Angle	A	1 39⅔	Right ascension of the New Star	0 38⅔

	P		
	. M.		P. '.
B	2	[Asc. Rect. Novae]	
C			

At 7h 58m. Azimuth from the west [P.] 145°, 30'. Altitude [P.] 36°, 45'.

- B: Pole of the equator [Polus Aequatoris]
- C: Pole of the horizon [Polus Horizontis]
- DEFG: The meridian [Meridianus]
- HF: The azimuth [Azimuth]
- HA: The elevation above the horizon [Elevatio supra Horizontem]
- IA: The declination [Declinatio]
- K: The intersection of the equator and the horizon [Intersectio Aequatoris & Horizontis]

		P.	M .		P.	'
Side	B	38	4	Place of the Sun	18	12½ ✕
	C		4			
Side	A	53	1	Right ascension of the Sun	34	10
	C		5	[Ascens. Rect. ☉]	9	
Angle	A	34	3	For the elapsed hours [Pro Hor.	11	30
	C		0	elapsis]	9	
	B					
Hence the side	B	28	2	Right ascension of the	10	40
	A		2	midheaven [Asc. r. mc.]	8	
Angle	A	10	1	Right ascension of the New Star	1	26
	B	7	4	[Asc. r. Novae]		

		M				P. '.	
		P. .				P. '.	
C							
At 8h 3m. Azimuth 146°, 0'. Altitude 36°, 20'.							
		P.	M.			P.	M.
Side	B	3	44	Place of the Sun		1	13 ⅗
	C	8				8	
Side	A	5	40	Right ascension of the Sun [Ascens. r. ☉]		3	10¼
	C	3				4	
						9	
Angle	A	3	0	For the elapsed hours [Pro Hor. elapsis]		1	45
	C	4				2	
	B					0	
Hence the side	B	2	21	Right ascension of the midheaven [Asc. r. m.c.]		1	55¼
	A	8				0	
						9	
Angle	A	1	26⅝	Right ascension of the New Star [Asc. r. Novae]		1	28½
	B	0					
	C	8					

On the Eleventh of March.

At 7h 50m. Azimuth from the west [P.] 149°, 30'. Altitude [P.] 33°, 30'.

		P.	M.			P.	M.
Side	B	38	44	Place of the Sun		1	6 ⅚
	C						
Side	A	56	30	Right ascension of the Sun		1	0½
	C			[Ascens. r. ☉]			
Angle	A	30	30	For the elapsed hours [Pro Hor.		11	30
	C			elapsis]		7	
	B						
Hence the side	B	28	20	Right ascension of the		11	30½
	A		½	midheaven [Asc. r. mc.]		8	
Angle	A	11	45	Right ascension of the New Star		1	45
	B	6	½	[Asc. r. Novae]			

		P.	M.		P.	M.
			C			
At 7h 53½m. Azimuth from the west [P.] 150°, 0'. Altitude [P.] 33°, 10'.						
		P.	M.		P.	M.
Side	B	3	44	Place of the Sun	1	6⅛ γ
	C	8				
Side	A	5	50	Right ascension of the Sun	1	0⅔
	C	6		[Ascens. r. ☉]		
Angle	A	3	0	For the elapsed hours [Pro	1	22
	C	0		horis elapsis]	1	
	B				8	
Hence the side	B	2	19	Right ascension of the	1	22⅔
	A	8		midheaven [Asc. r. m.c.]	1	
					9	
Angle	A	1	3⅔	Right ascension of the New	1	19
	B	1		Star [Asc. r. Novae]		
	C	8				

On the Fourteenth of March.

At 8h 2m. Azimuth 152°. Western. Altitude [P.] 31°, 43'.

			M		P.	'
		P.	.		P.	'
Side	B	3	4	Place of the Sun	4	40⅙ γ
	C	8	4			
Side	A	5	1	Right ascension of the Sun	3	44
	C	8	7	[Ascens. Rect. ☉]		
Angle	A	2	0	For the elapsed hours [Pro Hor.	1	30
	C	8		elapsis]	2	
	B				0	
Hence the side	B	2	2	Right ascension of the	1	14
	A	8	2	midheaven [Asc. r. mc.]	2	
					4	
Angle	A	1	4	Right ascension of the New Star	1	31
	B	2	3	[Asc. r. Novae]		

P. '.

A summary compilation, in the manner already found, of the right ascensions and declinations of the New Star.

ANNO	D I E S	Temp us H.	Temp us M.	Asc. Recta P.	Asc. Recta M.	Declinati o P.	Declinatio M.
1572							
MENSES.	3	7	52	1	25	61	45¼
December							
	3	8	16	1	24½	61	43⅓
	3	8	34	1	25½	61	41⅓
	3	9	16	1	36	61	42
	4	8	11	1	17	61	43½
	4	8	16½	1	47¼	61	43½
	1	7	11¼	1	32	61	44½
	0						
	1	7	14	1	19½	61	43
	0						
	1	7	20½	1	17⅝	61	45¼
	0						
	2	4	21	359	38½	61	44
	6						
	2	4	26½	359	41	61	42
	6						
	2	4	38	359	32¾	61	44½
	6						
	2	4	51	359	26¼	61	46
	6						
ANNO 1573	1	4	35	0	36	61	45¼
Ianuar:	1						
	1	4	36	0	36	61	44½

ANNO	D I E S	Temp us H.	Temp us M.	Asc. Recta P.	Asc. Recta M.	Declinati o P.	Declinatio M.
	1						
	1	4	37½	0	38⅔	61	45
	1						
<i>Februar:</i>	2	7	58	1	26	61	8 [recte: 44?]
	6						
	2	8	3	1	28½	61	39
	6						
<i>Martius</i>	1	7	50	1	45	61	39½
	1						
	1	7	53½	1	19	61	41
	1						
	1	8	2	1	31	61	38
	4						

From comparing all these values against one another, the disagreement in the declinations is not particularly noticeable, whereas in the right ascensions it is excessive—exceeding two full degrees in some places. This is not so much a fault of the instrument with which the azimuths and altitudes were taken as it is of the clock that marked the moments of time, and its unreliability. For an error in the clock, however slight in itself, turns out to be remarkably prolific, since four minutes of time induce a deviation of a whole degree.

It is clear from these results that on the very days when the observation was being made, the right ascension agrees better with itself, whereas the values for different days insinuate a more serious discrepancy. This plainly indicates that the disagreement crept in through a fault of the clock—either because it had not everywhere been properly set to the meridian, or because of one shift after another in the air occurring at different times, or indeed for several other causes that could have combined here.

This is the very thing I asserted in Chapter Two concerning this method of observing the positions of stars: that in so delicate a business one cannot safely trust to clocks. I also adduced several reasons why this should be so. That the matter does indeed stand thus, these very observations of the Landgrave [Wilhelm IV of Hesse-Kassel] make plain. For although the diligence applied in

them was without doubt by no means slight, the inconstancy of the clock nonetheless made them deflect too much from the intended aim.

Now if one chooses to take the mean of all these values, the right ascension comes out at $0^{\circ} 36'$. With this, the values taken on 11 January agree more closely; and so at least a discrepancy of one-sixth of a degree is committed relative to our own finding. The declination, however, agrees more conveniently around those same days of January at $61^{\circ} 45'$, in that it falls short of the truer value by at least two minutes.

But if from this limited right ascension and declination, taken with respect to the equator, we derive the longitude and latitude of the New Star [New Star of 1572] by trigonometric computation with reference to the ecliptic, the following results emerge, as I shall now show.

In the figure set alongside—of the same sort I also used earlier in investigations of this kind—the designations come to be understood in the same way as before.

Diagram. A spherical-triangle construction used for reducing the star's equatorial coordinates to ecliptic longitude and latitude. A large circle (the sphere) carries two great-circle arcs crossing within it, with the relevant triangle drawn near the top.

- B (upper area, left of C): vertex of the principal triangle
- C (top): vertex of the principal triangle
- A (center-upper, inside the triangle): pole / intersection point
- G (right edge): point on the circle
- F (lower right, on the circle): point on the circle
- D (left edge): point on the circle
- H (lower-center-left): intersection point
- K (lower-center): intersection point
- I (below K): intersection point
- E (lower left, on the circle): point on the circle

The side BA is the distance between the poles of the ecliptic and the equator, $23^{\circ} 31\frac{1}{2}'$, as we have determined it. CA is the complement of the declination, $28^{\circ} 15'$. The angle BAC, measured by the star's right ascension counted from the beginning of Capricorn [♑], is $90^{\circ} 36'$. Hence there results the side BC, the complement of the latitude, yielding $36^{\circ} 18'$, and the angle ABC, $53^{\circ} 2'$. [The text now turns to the difference] from the beginning

[p. 504] of Capricorn [♑], which it represents. Therefore, once this angle is subtracted from a quadrant, the star's elongation from the vernal equinox comes out at $61^{\circ} 58'$ Taurus [♉], coinciding with the latitude given earlier from the complement, $53^{\circ} 41'$ north.

This position of the New Star, examined in this way, exceeds the one we assigned to it from our various derivations in Chapter Five by at least four minutes, both in longitude and in latitude. That difference is quite moderate and scarcely worth mentioning. Indeed, when compared with the annotation of the most illustrious Prince himself, set down in letters written to the most distinguished and excellent man Caspar Peucer [Caspar Peucer] (which we shall bring forward in the following chapter), the longitude of the star agrees with our derived value to within a single minute, while the latitude falls short there by only five minutes—something that could easily happen through the mechanical investigation of the star's place on a globe, which he was using.

I judge, moreover, that at the moments of time when the azimuths and altitudes were being taken, the most illustrious Prince himself applied some other limitation, and was not altogether satisfied with these very moments in investigating the star's place. For he could correct them proportionally from a deficiency or excess in the clock's indication at the following noon, and so arrive more surely at the star's true right ascension. But since the more limited times were not transmitted to me, I had to use the very ones the documents contained. And so that discrepancy too—so evident in the right ascension, arising from these Landgravian observations—easily merits its own excuse. For it may well be that, using more corrected times, he found this discrepancy not so deformed after all.

The most illustrious Prince did indeed note everywhere the place of the Sun from certain of his observations; but since the Sun, especially in the beginning, was not far removed from the winter tropic, its declination changed only slightly from day to day, and therefore its longitude—which has to be derived from this—could be established less reliably. By approaching nearer to the autumnal equinox this could be done more safely and expeditiously; yet even here, unless the Sun's declination is established to within some fraction of a minute, the intended aim is not attained with sufficient precision. The difference that intervenes from collating the Sun's place with our own calculations will easily be evident.

Afterwards the Landgrave himself adds that he detected absolutely no proper motion in this star, and therefore did not continue his observations of it beyond the middle of March. From this it is clear that, however much the observations occasioned by the instrument might from time to time suggest some discrepancy

to him, he nevertheless reconciled it by disregarding it and composed everything into one unmoving place.

Furthermore, from the star's immobility, it is not obscurely plain that it is to be enrolled in that class which are called fixed [stars]; and in this respect, too, the Landgravian opinion agrees admirably with ours, which attribute to the star a perpetual quiescence.

[p. 505] It should be noted, further, that everywhere he properly calls it a New Star, and not a comet—as certain men have done, who, placing these too in the loftiest aether, have used the term improperly.

The most illustrious Prince himself likewise testifies, in letters sent to me, that he detected absolutely no parallax in this star, as will be evident from the volume of Astronomical Epistles—although, writing at that time to Caspar Peucer, he allowed a parallax of about three minutes (uncertain as he then was even about this), doubtless on account of a more correct elevation of the pole assumed for the sake of the correction—the matter of which quadrant he was then using, and how it was managed, we shall see more fully later. Let it suffice, then, to have said and inquired this much concerning the Landgravian observations of this star communicated to me. What can be gathered further from the letters written once and again to Peucer on this account, we shall consider presently, around the beginning of the chapter that follows.

D. Thaddaeus Hagecius ab Hayck, Bohemian

Concerning this wandering star a man preeminent as much in virtue as in excellence of learning, D. Thaddaeus Hagecius [Tadeáš Hájek], at that time Ordinary Physician of the Imperial Court, published a particular and erudite book. From the inauguration of Rudolph [Rudolf II], King of the Romans—who now presides over the reins of the Empire—celebrated at Regensburg on the Danube in the year 1575, he was joined to me in a long-standing friendship, first contracted there and afterwards continued through letters. He entitled this writing of his *Dialexis on the New and Previously Unknown Star, on the Apparition of Unaccustomed Magnitude and of Most Splendid Light, and on the True Place of the Same*, and comprised it in fifteen chapters; although afterwards, in revising and enlarging it, he added seven more, which, however, do not treat properly of this star but teach certain learned problems within the general subject of working out parallax. For he afterwards sent me this *Dialexis*, enlarged, in which what he had corrected and added were in manuscript, and not, so far as I know, ever yet published in type. Therefore, in working through and examining this

Dialexis of Thaddaeus—although his edition appeared in print many years ago now, and chiefly the printed one is in circulation, because that copy is in the hands of others and is still extant—nevertheless, where the matter itself requires it, I shall append certain things in the manuscript copy communicated to me, revised and emended, or even more fully assigned, so that what he restored more pointedly in these matters may be plain to others as well. And this at least as far as concerns those things which properly regard this star. For to repeat here what he treats generally about parallaxes would be too long. I know, too, that this is done with the author's good leave—that some things, though not published, be interspersed—for he himself, through his letters, freely granted me this.

In due order, then, I shall briefly weigh those fifteen chapters, and, for the sake of eliciting and confirming the truth by observations, I shall ponder their contents together with our own sky and our own findings.

[p. 506] **Chapter One.** From the outset, concerning this star's magnitude, splendor, and form, as well as the time of its apparition, he sets forth in a general way some things not greatly at variance with those we proposed in Chapter Four when treating of this matter—except that he equates this star, in visible size, to Arcturus, the Dog-star [Sirius], Mars, or Jupiter at the very beginnings of its outpouring, whereas in fact it then somewhat exceeded even these very stars in visible magnitude, so much so that it most closely rivaled Hesperus [Venus as evening star] when nearest to the Earth. On this point the most illustrious Prince Wilhelm the Landgrave agrees with us very closely, so much so that he did not hesitate to pronounce it to have been somewhat larger even than the star of Venus—as is plain from what is written above. But these matters must be understood as holding good according as the star of Venus is seen now to contract, now to relax, its apparent diameter as it is more or less distant from the Earth. On this point, too, Thaddaeus differs from us a little, in saying that this star had a ruddy splendor from the beginning, whereas it rather displayed a whitish light like that of Jupiter or Venus; and for this reason the said illustrious Prince, comparing it to the brightness of Venus, set it forth likewise as the more brilliant. As for the change of color, from whitish to yellowish, and then a little after the beginning of the following year '73 to ruddy, this we have more fully and specifically indicated in its own place. But this little discrepancy concerning the magnitude and color of this star, between D. Thaddaeus and me, is of no great moment. For both, according to the variety of the air's purity and the keenness of the observers' sight, those things could vary somewhat differently; and he himself confesses that he first caught sight of it around the Nativity of Christ, when indeed its visible size had somewhat diminished and the brightness of its whitish

color was beginning to change into a yellowish tinge, transmuting more and more from day to day.

Thaddaeus next subjoins a certain figuration, by which he wishes to express how this star, together with the three more notable stars of Cassiopeia, formed a rhomboidal figure, with lines drawn here and there from one star to another, to which he had also assigned the intervals. But because that representation was not sufficiently neat, nor did it set forth the figure of the rhombus so aptly as these stars together with the New Star formed it, he delineated another, more correct, in the recognition of the *Dialexis* transmitted to me; he added also, to the rest, that eleventh little star near which the New Star stood; and he had likewise altered somewhat certain distances in this latter figuration. So that it may be before one's eyes with what disposition he renewed these things, I shall subjoin his own design, drawn in the same form in which it was depicted in the more correct script; and at the same time I shall append how this delineation of ours, according to our own findings, comes out as regards the intervals of the like stars —so that, the collation made, whatever little difference there may be, though it be scarcely perceptible, may be recognized.

A representation of the arrangement of the New Star in relation to certain of the principal stars of Cassiopeia, drawn up with a fitting delineation and according to their mutual intervals

following

Diagram. The left-hand of two side-by-side figures, headed "the Recognition [revised reckoning] of D. Thaddaeus Hagecius [Tadeáš Hájek]." It shows a roughly diamond-shaped (quadrilateral) configuration of stars of Cassiopeia with the New Star at the bottom, the connecting lines labelled with their angular intervals in degrees and minutes. The vertices and the values along the connecting lines, as read on the page:

- A (top): "II" with a star-burst — the star at the top of the figure.
- B (right): "III" with a star-burst.
- C (left): "XI" with a star-burst.
- D (bottom): "NOVA" — the New Star, with a star-burst.
- A small star lettered "XI" near the lower middle, between C/B and D (the figure's star #11); a bare "5" sits just to its lower-right as a separate line/interval value — it does not mark the star.

- Line A–C (upper left): 4.57.
- Line A–B (upper right): 4.42.
- Line A–B (vertical, central, A down through to B): 7.47 — printed as "7." with "47." below along the central vertical.
- Line C–B (horizontal, across the middle): 6.14.
- Line C–(lower star): 4.46.
- Line C–D (lower left, outer): 5.15.
- Line B–(lower star) / inner lower right: 3.46 and 3. (two values along the converging lower-right lines).
- A value near the central lower star: 1.21 [?] (partly obscured).

Diagram. The right-hand figure, headed "Our own Notation of the same [stars]." A parallel diamond-shaped configuration with the same lettered vertices but Brahe's own interval values:

- A (top): "II" with a star-burst.
- B (right): "IIII" with a star-burst.
- C (left): "XII" with a star-burst.
- D (bottom): "NOVA" with a star-burst.
- A star marked "XI" with an "E" beside it, in the lower middle.
- A central-lower overlapped numeral beneath the E/XI star: [?] (present on the figure but struck through by the converging rule-lines and glyph-by-glyph illegible — value not committed).
- Line A–C (upper left): 4.59.
- Line A–B (upper right): 4.40.
- Line A–central vertical: "7." with "50½" below (i.e. 7.50½). [The ½ is legible; the small mark below "50½" is a printed subscript/abbreviation tick, not a further digit.]
- Line C–B (horizontal, across the middle): 6.12½.
- Line C–(lower middle): 4.44.
- Line C–D (lower left, outer): 5.19.
- Line B–(lower middle), inner: 3.35 and a value "2." beside it.
- Line near the lower-middle star (E/XI) to D: "5" (lower right outer).

It is therefore clear that Thaddaeus drew up a figure somewhat different from his earlier one, and a more correct one, which also agrees very closely with our own.

I have not thought it worthwhile to add here that older figure of his earlier *Dialexis*, since through some carelessness it was set out there far too inaccurately.

As for the distances at which the stars were placed in that figure, this can be gathered from the intervals then presupposed, which we shall add shortly.

He then compares some of his own distance-measurements with those that Munosius [Jerónimo Muñoz] the Spaniard had reported, and where they differ he defends his own — though in some of these he subsequently changed his mind and came closer to Munosius's observations. But if our own distances are brought to bear on those of Thaddaeus and Munosius, this dispute is easily settled; for in our figures there is not the error of a single minute [scrupulus].

He next appends the intervals of the New Star from several stars in the asterism of Cassiopeia, and also the intervals of certain stars of that same constellation among themselves and with respect to Cynosura [the Little Bear / Polar region], inasmuch as he determined these from the sky itself and not from the numbers of the Tables.

First, however, I shall set out what intervals Thaddaeus established in that older *Dialexis*, and afterwards how he corrected most of them, a comparison having been made in both cases with our own observations of the same stars.

The distances of the New Star from certain stars of Cassiopeia, and of these among themselves, as they were determined in the published *Dialexis* of Thaddaeus, a comparison with ours having been made.

Ord	Nomina Stellarum	Thaddaei G.	Thaddaei M.	Nostrae G.	Nostrae M.	Differ.
	NOVA STELLA ab (New Star from)					
11	Erectione Sedis	1	24	1	31	7 plus
12	Lucida Cathedrae	5	15	5	19	4 pl.
2	Schedir	7	47	7	50½	3½ pl.
3	Cingulo	7	0	6	53	7 min ⁹
4	Flexura	4	51	5	2	11 min.

O rd o	Nomina Stellarum	Thaddaei G.	Thaddaei M.	Nostrae G.	Nostrae M.	Differ.
	Cynosura	25	30	25	14	16 min.
	Vndec. à (Eleventh [star] from)					
2	Schedir	6	30	6	27	3 min.
3	Cingulo	5	24	5	23	1 min.
4	Flexura	3	46	3	35	6 min.
1 2	Lucida Cathedr.	4	45	4	44	1 min.
	Cynosura	26	34	26	26	8 min.
	Secunda à (Second [star] from)					
1	Capite Cassiopeae	2	31	2	41	10 pl.
3	Cingulo	1	54	1	42	12 min.
4	Flexura	4	36	4	40	6 min.
1 2	Lucida Cathedrae	4	55	4	59	4 pl.
1 1	Erectione Sedis	6	30	6	27	3 min.
	Tertia à (Third [star] from)					
1 2	Lucida Cathedrae	5	16	5	19	3 pl.
	Quarta à (Fourth [star] from)					
3	Cingulo	3	0	3	3	3 pl.
5	Poplite	3	36	3	35	1 min.
6	Crure	7	20	7	19	1 min.
1 2	Lucida Cathedrae	6	14	6	12½	1½ min.

O rd o	Nomina Stellarum	Thaddaei G.	Thaddaei M.	Nostrae G.	Nostrae M.	Differ.
	Cynosura	28	35	28	36	1 pl.
	Quinta à (Fifth [star] from)					
6	Crure	4	53	4	50	3 min.

This, then, was how Thaddaeus had at that time arranged these intervals; but afterwards, examining them more carefully, he altered most of them somewhat, and in certain letters sent to me he noted some of them more accurately — values which he asserted, repeated many times over, to be the truest — and these same ones he afterwards restored in the revised *Dialexis*, deleting the earlier ones. They are as follows.

Certain more correct distances drawn from the foregoing, following Thaddaeus's later determination, with our own intervals also applied.

O rd o	Nomina Stellarum	Thaddaei G.	Thaddaei M.	Nostrae G.	Nostrae M.	Diffe r.
	NOVA STELLA ab (New Star from)					
11	Erectione Sedis	1	26	1	31	5 plus
4	Flexura	5	3	5	2	1 minu s
	Vndecima à (Eleventh [star] from)					
4	Flexura	3	36	3	35	1 min.
12	Lucida Cathedrae	4	46	4	44	2 min.
	Secunda à (Second [star] from)					

O rd o	Nomina Stellarum	Thaddaei G.	Thaddaei M.	Nostrae G.	Nostrae M.	Diffe r.
1	Capite Cassiop.	2	35	2	41	6 pl.
3	Cingulo	1	45	1	42	3 pl.
4	Flexura	4	42	4	40	2 pl.
12	Lucida Cathedrae	4	57	4	59	2 pl.
	Prima à (First [star] from)					
3	Cingulo	4	21	4	17	4 pl.
	Tertia à (Third [star] from)					
4	Flexura	3	2	3	3	1 pl.
	Quinta à (Fifth [star] from)					
6	Crure	4	48	4	50	2 pl.

These, then, were the distances of D. Thaddaeus, recorded in a corrected and fuller version. Here it should be noted that wherever there was a discrepancy in the letters I have mentioned from the numbers corrected in the *Dialexis*, I have adopted those that come closest to our own, because they are the more probable. I wished to point this out so that, if that revised *Dialexis* should ever come to light, and the distances should not everywhere be corrected as we have indicated, readers may know that these were arranged by me from a certain annotation in manuscript transmitted by D. Thaddaeus. [?]

Now, as to how the distances — both the earlier and the corrected ones — differ somewhat from ours: the assigned discrepancy makes plain in each case whether we found more or less on either side. Although in some places this is very small and of no consequence, in others it is nonetheless too evident, especially in the distance of the New Star from Cynosura, where it exceeds by a quarter of a degree. That this cannot stand is sufficiently proved by the very distance of the New Star from the Pole, found by means of the Complement of the Declination, 28° 13' [p. 28 /. 13]. For since Polaris was then 2° 59' [p. 2 /. 59] distant from the Pole — as is plain from the Hainzel [Johann Baptist Hainzel] observations recalled in their place — when our distance of the New Star from Polaris, 25° 14' [p. 25 /. 14], is added, its remoteness from the Pole comes out in agreement with the Complement of the Declination. Nor could the difference be at all perceptible,

since the New Star and Polaris crossed the meridian at very nearly the same time. It is therefore established that our interval is correctly determined.

But on Thaddaeus's reckoning [placita] it would have come out as the Complement of the Declination of the star $28^{\circ} 29'$ [p. 28 /. 29], making its declination 16 minutes too small [16 scrupulis iusto minorem], and disagreeing with his own reckoning, while [he makes] the star's remoteness from the Pole,

or rather the Complement of the Declination, come out at $28^{\circ} 7'$ [p. 28 /. 7] in the very course of his text. The remaining differences are obvious enough; and if the heavens themselves are inspected more precisely, with instruments by no means deceptive, it will certainly appear that our intervals hold good to within the very minute — and that in truth, relative to the quantity assigned, Thaddaeus sometimes noted more, sometimes less, than the exact interval.

Finally, he sets down the positions of the stars of Cassiopeia according to the Copernican enumeration; how far these differ from the sky is plain from our verification, given in Chapter Five [Cap. Quinto], and from a comparison made with it. But that in this arrangement he anticipated the last star — the one numbered 13 — by more than a whole Sign, he did in imitation of the makers of astronomical tables [Abacorum], who all go astray to such an extent in the case of this star.

He likewise appends to these an image [picture] of Cassiopeia, as the positions of the stars he set out require — except for that star 13, which deviates too far. But what these figures are like, and where they here and there depart from our own (taken from the heavens, not from the numbers of the catalogues), and the discrepancy in the proper marking of the stars, will be seen if anyone compares our picture of Cassiopeia, presented in Chapter Three [Capite Tertio], with that of Thaddaeus more carefully.

The position of the New Star in his own figure he himself saw to be lowered too directly beneath the eleventh star; and for that reason, in the corrected copy, he raised its place a little higher, obliquely. And this is enough concerning the First Chapter.

In **CHAPTER TWO** [Capite Secundo] he reports and refutes various opinions of others about this Star: in part those who contended that it was not a New Star but one of the old stars miraculously illuminated; in part those who held it to be sublunary. On these I shall add nothing further here, since he himself separately calls back to the anvil [reexamines] the opinions both of those he there cites and of others. He also discusses learnedly, in the same Chapter, that this Star was not

a comet, nor was it like that one which appeared in the time of the Magi [the Star of the Magi]; and that the Philosophers' Axiom — that the Heaven does not admit new generations — is not sufficiently established, just as we too have asserted this and the like everywhere.

In **CHAPTER THREE** [Capite Tertio] he maintains that this Star is utterly New and, contrary to the order of Nature, set in the aether; and he brings forward most things which, as to the general consideration of it, are not at variance with ours — concerning its Place, Species, Magnitude, Alteration, and Scintillation. That it was indeed truly New he proves by sufficiently evident arguments, in which, were it not for the ignorance and dull-witted prejudice of others, there would have been no need in a matter so manifest.

For those who presumed to deny that this Star had newly arisen made it plain that they had either no knowledge at all, or only a slight one, of the stars, and that they were utterly blind — so much so that they deserve to be met with laughter rather, and to be passed over with mere rejection, than that they should merit a laborious refutation.

Chapter Four

In this chapter Hájek argues learnedly that comets and secondary stars can be generated in the aetherial region as well as in the elementary region. He reviews a number of comets noted by both ancient and more recent writers — some of which he judges to have been elementary, others truly celestial. He then also discusses that Hipparchan star which Pliny [Plinius] mentions, and here he agrees with me entirely: it was not a comet, but truly a new star created in the heavens themselves. Let me add his own words, which he had noted in the margin of the revised copy and which are to be found separately at the end of the earlier *Dialexis*:

Note, I beg you, these words — that he plainly calls it a New STAR, and another star besides, namely one of those that were created in the firmament at the beginning of the founding of the world by GOD. He does not seem to have understood it as a comet, for he would not have said "a New Star," but simply "a comet"; or, at least for the sake of distinguishing it, he would have qualified it as "a tailed star," unless one cared to say that comets were unknown to him.

I treated these matters more fully in Chapter Three, where I showed that Pliny affirmed that Hipparchus had truly detected a new star. For Pliny too, in his Chapter 24, is entirely of this opinion — that stars are produced in the heavens themselves. He says as much: *For in the heavens themselves stars are suddenly*

born; there are several kinds of them, even though the interpreters have corrupted these words. And how mistaken they are in this is clear from those passages where the chapter that soon follows — Chapter 25, in which he treated of the various kinds of comets — closes thus: *There are those who believe that these heavenly bodies are perpetual and travel in their own circuit, but are not seen except when lit by the Sun; others, however, hold that they are born of chance moisture and of fiery force, and are therefore dissolved.* This last opinion, which is the Aristotelian one, Pliny does not approve; otherwise he would not have relegated it to the last place as the less probable.

Therefore, in the point on which Hájek there concedes that comets can be generated in the aether, I support him entirely. For this has in fact proved to be the case with several comets observed afterward, as I demonstrate clearly in the following books — and notably in that splendid comet seen in the year 1577, which Hájek himself did not at first hesitate to place in the elementary region, though afterward, once the whole matter had been better examined, he changed his view and assigned it to its proper place in the celestial world. But in the point where he also admits that some comets are generated below the Moon, I in no way agree with him. For I have no doubt at all that all bodies which are truly comets (I am not speaking here of vapor-trails and fiery meteors) are produced entirely above the Moon, in the aetherial region of the world — as I shall explain why I rightly hold this view in certain large corollaries set around the Epilogue of the whole work.

What moved Hájek was the authority of Aristotle [Aristoteles], who asserted that all comets are sublunary; and so he did not hesitate to grant that comets occur more frequently in the elementary world than in the celestial. And what chiefly drove him, after the Aristotelian decrees, were the mathematical observations and conclusions of Regiomontanus [Regiomontanus] and Vögelin [Vogelinus] on two comets, by which they had assigned to them parallaxes much greater than those of the Moon. But as for the work of these craftsmen —

— however eminent it is, especially in such matters, their determinations are not established with such fixed certainty that they cannot be called into doubt, inasmuch as they are less than duly consistent, and the requisite diligence and subtlety were not applied. These things I shall, in their proper place, lay open to those lovers of the truth who delight in what lies hidden.

Aristotelian arguments, although sufficiently thorny and plausible, nevertheless rest upon a merely probable conjecture rather than upon sure experience or a geometrical demonstration drawn from competent observations. And so, among

those who investigate what truly is, rather than what is supposed to be, they do not deserve approval. Nor is his authority so great that it can derogate from the truth and from the more evident demonstrations of the mathematicians, merely because it has been held authoritative for so many ages now. Aristotle himself admits that his conclusions on the whole of meteorological doctrine are at least conjectural and based on guesswork [*Stocasticas*]. Had he plainly stated them to be false and worthless, he would have understood himself and his own science far better. For the things he sets forth about ordinary meteors are by no means entirely as he describes them, since their generation is far otherwise than he dreamed — but this is not the place to discuss the matter.

That argument which Hájek proposes in the same chapter, drawn from the comets' own proper motion — namely, that comets which move more swiftly than the Moon, being carried contrary to the Primum Mobile, are below it, while those which move more slowly are above it — is deduced, as he says, from Aristotelian principles. And to satisfy his followers, it does not seem to me sufficiently apodictic. For comets can be carried by their own motion in a swifter course, either forward or in consequence, or even sideways toward the poles, than the Moon herself, and yet not by any means be situated below her. Nor does that reality of the orbs, which Aristotle attached to the heavens, in fact exist in them, as I shall make abundantly manifest elsewhere. Comets have their own peculiar laws of motion, exempt from the prescribed course of the planets, by which they are borne more swiftly or more slowly as the force impelling them happens to carry them, with no regard for the cycles about which their revolutions take place. So too they sometimes do not oppose the diurnal motion, but run ahead of it, racing toward the west — which nevertheless does nothing to place them above or below the Moon, for that must be sought from another source, from the parallaxes themselves. But of these matters I shall treat more amply elsewhere.

Nor ought it to seem surprising that Hájek, a man otherwise most devoted to the truth, could not so suddenly assent that all comets are confined within the bounds of the heavens, when that inveterate opinion had so prevailed — especially with the votes of Regiomontanus and Vögelin in agreement — that something seemed bound to be conceded to it. For so it is humanly arranged that one is not allowed to abandon all at once views long received and approved, even if erroneous, but the exchange from darkness into light comes about only gradually, just as we see at the breaking dawn, which supplies us the daylight not suddenly but step by step, until the Sun itself, once risen, drives away all the

shadows. Something of this kind appears to happen also in the business of religion, and one may hope that —

— just as the dawn never slips back into the darkness of night, even though now and then its advance is obscured by thicker clouds, so also the Truth itself — whether theological or philosophical — once it gradually emerges from the wrappings by which it was clouded over, will not suffer any retreat.

At the end of the same chapter Hájek touches on a few things about the generation of comets in the heavens. Although he frankly confesses that he is ignorant of this, he nonetheless does not deny that it can come to pass; but he piously ascribes to the wondrous works of GOD the manner in which it happens, and asserts that it is removed from our full understanding — which I too do not deny. Yet such things as can be probably estimated about their production, beyond the commonly philosophizing opinion, I shall signify (with the favor of the Author of the heavens) toward the end of the whole present work, at the close of my Third Volume. Meanwhile I am not unwilling to agree with those who maintain that comets are to be placed among the secrets of Nature not yet explained, and assert that they arise from hidden causes — as Regiomontanus proves from Messala. But now let us come to the Fifth Chapter, in which he sets forth what particularly and chiefly concerns this New Star.

Chapter Five

Here he labors to prove that this unusual star does not belong to the sublunary world but is to be fixed in the heavens themselves. First, in a broader manner, he establishes this from the uniformity of its motion and its perfect concurrence with the universal revolution; afterward, he confirms the same from its lack of parallax. He intersperses, however, certain empty opinions of others who placed it in the sublunary air, not very many semidiameters removed from the Earth — which I am reluctant to report further. Coming rather to the matter itself, we shall here bring forward, from the said chapter, his very words by which he strives to establish the imperceptibility of the parallax — and this as it stands in the later copy revised after transmission, where most of it is set down somewhat differently than as it was published, together with some matters there altered in the demonstration, or rather amplified by an enlarged induction.

From the Fifth Chapter, revised, of Hájek's *Dialexis*, where he proves that this star was aetherial.

Every body that either has no parallax, or a smaller parallax than the Moon, is by no means to be reckoned to the elementary region, but to the aetherial. Our star

has been found to have no parallax. Therefore it is to be reckoned not to the elementary but to the aetherial region. The major premise is evident from the doctrine of parallax. The minor I prove by the present demonstrative prosyllogism.

Every body that perpetually and everywhere keeps an equal distance from the poles of the world and from the stars can have no parallax. Our star keeps an equal distance from the pole of the world and from the stars at all times and in all places. Therefore it can have no parallax.

But this will be made still more evident from the following diagram and geometrical argument, which I have thought fit to subjoin, so that the truth may stand firm and each branch of knowledge concerning this star may be established. The major premise —

— of the prosyllogism is known from the doctrine of parallax, which there is no need to thresh out here at greater length. The minor is made evident by my own observations and those of other learned men — especially of Cornelius Gemma [Cornelius Gemma] and of the Spaniard Jerome Muñoz [Hieronymus Munosius, Jerónimo Muñoz] — and so too by the following demonstration of mine.

Diagram. A large circle representing the meridian, with several arcs and points marking the position of the new star relative to the pole of the world and the horizon. The accompanying text gives the construction: let the meridian be AZHB, in which the zenith point is Z, the middle of the eastern horizon is AEB, point B the rising of the equator, the altitude circle ZOM, and the pole of the world H. The relevant labeled points and lines are as follows.

- Z (top): the zenith [*verticis*]
- K (top, right of Z): point on the upper arc
- H (upper right, interior): the pole of the world [*Polus Mundi*]
- G (interior, near center): point on the arc toward H
- O (center): the second-observation position of the star, on the altitude circle ZOM
- F (right edge): the first-observation position of the star
- A (left): western end of the horizon / meridian
- B (right): point of the rising of the equator
- E (bottom center): point on the lower meridian / horizon arc
- M (bottom, right of E): foot of the altitude circle ZOM

Let the meridian be AZHB, in which the zenith point is Z, the middle of the eastern horizon AEB, point B the rising of the equator, the altitude circle ZOM, and the pole of the world H. The place in which, at the first observation, the star stood exactly to the north and in the lower part of the meridian, on the 6th of May at hour 8, minute 29 after midday, at Vienna under an elevation of the pole of 48 degrees 22 minutes, let this be F. From here the star — that point F — is understood to have been carried by the motion of the Primum Mobile, advancing into the middle of the eastern heaven toward E, to the point O, over a time of 24 minutes 38 seconds [*scrup.*], or over 1 hour 38 minutes, which time was 10 hours 7 minutes.

The altitude of the fourth star in Cassiopeia [Cassiopea], which at that time was found, he stated to have been 17 degrees 45 minutes. But at point F, where the New Star was observed at the first observation, it had an altitude, taken by the quadrant, of 20 degrees 15 minutes, marked by the arc BF, whose complement to the altitude of the pole is the arc FH, 23 degrees 7 minutes. Point O of the firmament, in the second consideration — at the hour, as we said, of 10 hours 7 minutes — had an altitude of exactly 22 degrees, marked by the arc MO. The horizontal distance from the north toward the east of the middle of the heaven, marked by the arc BM, was 12 degrees 13 minutes.

Now, if the place of the star in the second consideration be found on the semicircle FOK, which is described by the motion of the firmament, the star will have no parallax. But if it be found within the said semicircle, and not distant equally from the pole of the world, then it will have some parallax. And so that this may be more rightly known, we affirm the triangle ZHO, in which the sides ZO and ZH are known, together with the angle OZH. Therefore, by Copernicus XI, the side OH becomes known as 28 degrees 7 minutes. But from the first consideration the side FH was found to be of the same degrees and minutes. The star, therefore, observed in F and O, is equally distant from the pole of the world; it is moved in the parallel FOK by the motion of the Primum Mobile; and it does not vary on account of any visual displacement. In short, point F will be at once the true and the apparent place of the star.

Again, since in the second observation this new Phosphorus [*Phosphorus*, the morning star] was carried over to O through the arc FO from the meridian toward the east, as was said above, I say that it likewise keeps in that place the same distance from the pole of the world as before, and has no parallax. For if not, it will necessarily follow that its true place be fixed on the arc OZ above the point O — say, at G. Let the arc HG of a great circle be drawn from the pole of the

world. Since by observation the angle GHF is given as a time of 24 minutes 38 seconds, there will therefore be given the angle ZHG adjacent to it, 155 minutes 22 seconds. But the side HZ is known. Hence, by Copernicus 12, the side HG becomes known, 28 degrees 7 minutes. You see that the side HG is equal to the side HO and to HF, and likewise that the angle GHZ is equal to the angle ZHO, when the side HG ought to have been less than the others, and likewise the angle ZHO —

the arc ZHO is greater than the angle ZHG, as the whole is greater than its part. But here the whole would be made equal to the part, which is absurd. Therefore the true place of our Phosphorus [Phosphori — the planet Venus] must not be separated from its apparent place.

To this I will add yet another method, an elegant and exquisite one, for investigating parallax. Look closely at the diagram given above. In it the triangle HOB has its two sides HB and HO known, and the angle at H is known. Therefore, by the eleventh proposition of Copernicus [Copernicus, *De Revolutionibus*, I.11] the side OB will be found; and at the same time the angle OBH, together with the rest, will not be unknown with respect to the right angle OBM. So I have once again the right triangle OMB, in which two sides, OB and MB, and the angles, are known. Hence the arc OM of the altitude-circle of the second observation will also be easily found. Since the observation answers to this result, we conclude that this star admits no parallax. For if, by a true observation, the star had been found higher, then there would have been some parallax. It could not, however, have appeared lower by reason of variation.

In this way Thaddaeus [Thaddaeus Hagecius / Tadeáš Hájek] sought to prove the imperceptibility of this comet's parallax. Granted, what he brings forward agrees admirably with the truth; nevertheless, given the magnitude of the matter and the subtlety of the inquiry — which demanded a fuller and more evident demonstration — he seems not to have done full justice to the whole business. As for his first syllogism, there is no doubt that phenomena having a parallax smaller than the Moon's must necessarily lie above it. So too with what he introduces in his second argument from the star's distance being everywhere equal and the same, and from its perpetual conjunction with neighboring fixed stars and with the pole: these establish well enough that the star has been altogether free of parallax. The converse, however, does not follow — namely, that any phenomenon which keeps an unequal distance from the fixed stars is for that reason subject to a perceptible parallax. For it can have a proper motion of its own that alters its distances independently of parallax, as happens in the case

of Saturn, whose parallaxes are scarcely perceptible, and which nevertheless does not keep an equal distance from the neighboring fixed stars within a single revolution of the heavens. But of a phenomenon that does not undergo any proper motion these things are rightly said. Indeed, if it keeps a constant interval from the neighboring fixed stars, however the universe revolves in its motion, it will follow that it has neither a proper motion of its own nor any [motion] that, by the principle of parallax, would arise accidentally and so be admitted.

Therefore Thaddaeus's reasoning stands sound, even though some have later perverted it concerning comets and turned it to abuse. Only this much I miss here: that he asserts simply that this New Star kept everywhere a like distance from the fixed stars and from the pole, but does not prove this very point from manifold and verified observations. For someone else might just as quickly deny this smaller [distance] as he affirms it, unless he is convinced by clear demonstrations. Thaddaeus does not there recount what the New Star's distances from the neighboring fixed stars were — both at the height of the sky and near the horizon, and toward each side of the meridian — perhaps presupposing them to be everywhere the same as those he noted in Chapter 1; yet if he meant to say this, he ought to have indicated it here as well.

And although he asserts that the star was equally remote from the pole everywhere, he nonetheless assigns it, at the zenith of the sky and where it was least subject to parallax, a maximum altitude which, when compared with the minimum, [he claims shows] that the interval is imperceptible in both cases.

That it [the star] showed a difference from the pole — which, had he done so, would surely have proved more fully and evidently the very thing he aimed to prove. But, as I judge, lacking the convenience of instruments [Mediorum] and of a [suitable] place, he refrained from observing its maximum altitude. He does, however, appeal to the observations of others, especially those of Cornelius Gemma [Cornelius Gemma] and of Jerome Muñoz the Spaniard [Hieronymus Munosius / Jerónimo Muñoz]. Would that these had been so precise and reliable that what he wishes to infer from them might deserve no doubt at all on its own account. Yet, so that Thaddaeus might add some demonstration to prove that this star revolved at an equal distance from the pole and admitted no parallax, he made use of the method of induction first laid down. This method, though indubitable in itself as far as the geometric proof proper is concerned, [runs into trouble] when, in the first observation, he says the star, situated at F, was elevated $20^{\circ} 15'$; while, when it came to the point O by the carrying of the *primum mobile*, he raises it to exactly 22° . Thus its altitude would have increased in the

interval by only one degree and three quarters; and surely from so slight a variation of elevation it would scarcely be granted that the parallax could be discerned, even with the largest instrument, even if the phenomenon had been a little below the Moon.

For let us suppose this star to have been in the nearest hollow of the lunar orb: it necessarily follows that at an altitude of $20^{\circ} 15'$ it admitted a parallax of $1^{\circ} 1' 40''$ [P. 1. / 1. // 40]. In the other [position], when it was elevated 22° , it would have had the same parallax of $1^{\circ} 0' 52''$ [P. 1. / 0. // 52] — as may be gathered from the very Table of Parallaxes which Thaddaeus afterward appends, [computed] at a distance from the Earth of 52 semidiameters and 17 minutes [52 Semidiametrorum /.17], such as is the Moon's nearest [distance]. The difference between the two parallaxes, therefore, would not be one minute, but only 48 seconds — which is indeed an extremely small discrepancy, not sufficient to discern by it the imperceptibility of the parallax. For the instrument would have had to be enormous, and the observation exact; and if the discrepancy did not exceed so minute a difference as does not reach a single scruple [unit], reliance would have to be placed [elsewhere]. And if [the star were] still higher, at 200 semidiameters (for example) — the distance from which he afterward drew up his Table of Parallaxes — the phenomenon would be raised, and the parallax-difference would scarcely make up a sixth part of one minute, which is altogether imperceptible. But going all the way up to the [eighth] sphere, and ascending to the Sun's, only $5''$ [//.5] of difference would be suggested. By no means, then, did Thaddaeus bring forward data sufficiently evident for asserting the total absence of parallax in this star. Moreover, he used some quadrant which exhibited only five separate scruples [i.e., graduated only in units of five minutes] — as is plain from this: that he gives the star's minimum altitude as, beyond whole degrees, exactly 15 minutes; and in the second altitude, precisely 22 degrees without any minutes; while he presupposes the assumed star of Cassiopeia [Cassiopeia], besides the degrees set down, to have had 45 minutes — so that he never applies a precision finer than five minutes. This is an indication that he used some quadrant which did not exhibit a finer subdivision of degrees than that of five scruples; and therefore he could in no way be certain of the individual [minutes], much less examine, by the mediation of that [instrument], any fractional part of a minute.

How then, I ask, could it be so beyond doubt, in the second observation — granting that the first was correct — that the star was elevated precisely two degrees, with no scruple wanting? For someone might object that the star was at that time lower by one or another minute, and that, owing to the smallness of the

instrument, this could not be discerned. And surely, if we make the second altitude even one minute lower, the New Star will not at all deserve to hold a place in the highest aether, which is what Thaddaeus aims to prove, but will be depressed somewhat below the Moon. Yet for that single minute Thaddaeus himself would not have pledged his word. Indeed, from the minimum altitude itself, compared with the elevation of the pole at Vienna of $48^{\circ} 22'$ [part. 48. /. 22], as Regiomontanus [Regiomontanus] observed, the star's distance from the pole comes out as $28^{\circ} 7'$ [part. 28. /. 7]. Hence its declination [comes out as] $61^{\circ} 53'$ [part. 61. /. 53], which exceeds, by six scruples, the star's true declination as verified by us in many ways and confirmed in Chapters Four and Five [Cap. Quarto & Quinto]; so that not even within five minutes was Thaddaeus's quadrant precise enough — unless perhaps in the elevation of the pole at Vienna as given by Regiomontanus 6 scruples are wanting. For one or the other of these must necessarily be the case.

There is this, too: that, since in this calculation [Pragmatia] he employs an interval of time which could scarcely be established as precisely as is required down to some fractional part of a minute, the angle OHF [o H F] is likewise not free of all suspicion, having a value somewhat otherwise than [supposed], so that nothing certain can be concluded.

Thaddaeus did indeed suppose that, from the altitude of the star of Cassiopeia which is numbered the 4th, he had obtained the moment of time precisely enough; yet, even granting that its altitude was observed precisely to the very minute as he cites — which is not free of ambiguity in itself — he will not for that reason elicit that 10 hours 7 minutes [Hor. 10. /. 7] had elapsed from the meridian exactly. Rather it was 10 hours $9\frac{3}{4}$ minutes [H. 10. /. $9\frac{3}{4}$]. That is, taking the truer place of the Sun, which was then at $25^{\circ} 37'$ Taurus [P. 25. /. 37 8], together with a right ascension of $53^{\circ} 17'$ [R. P. 53. /. 17], and applying the place of the star as verified by us, at $8^{\circ} 3\frac{1}{2}'$ Taurus [P. 8. /. $3\frac{1}{2}$ 8], with a latitude of $48^{\circ} 46' N$ [P. 48. /. 46 B]. For the star's distance from the meridian comes out, in degrees of the equator, as $197^{\circ} 39'$ [P. 197. /. 39]. If to this is added its right ascension of $7^{\circ} 56\frac{1}{2}'$ [Asc. R. P. 7. /. $56\frac{1}{2}$], the right ascension of the mid-heaven is composed as $205^{\circ} 35\frac{1}{2}'$ [Asc. Rect. MC. P. 205. /. $35\frac{1}{2}$]. Hence, if the right ascension of the Sun is subtracted, there results an arc of the equator elapsed from the meridian of $152^{\circ} 18\frac{1}{4}'$ [P. 152. /. $18\frac{1}{4}$]. To this corresponds 10 hours $9\frac{1}{4}$ minutes [Hor. 10. /. $9\frac{1}{4}$], as we said. The true time, therefore, collected from the given altitude of the star, exceeds his own notation by two minutes and one quarter. Although this may seem trifling, it nevertheless renders the angle at H, however reckoned, larger by 34 minutes [34 min.]. And so it somewhat disturbs the induction of the

demonstration, so that not everything coheres as he intended. Furthermore, this star of Cassiopeia, by which he was investigating the time, was removed not far from the meridian — by 17 parts [17] at most — and therefore its altitude varied too slowly for it to be safe to investigate the precision of time from it.

I pass over, besides, that the finding of the azimuthal angle MZB [m z b] is precarious and more liable to deviation than the inquiry into the altitude itself.

From all of which it follows that the data which Master Thaddaeus employed were not exact enough, nor in every respect sufficiently suited to so subtle an inquiry to support a solid investigation. For the least and scarcely perceptible error in them could have furnished a quite open occasion for a deviation in the parallax. The same must be understood of what he adds further from the triangle OMB: since these depend on the foregoing and stand or fall with them.

I do not mention these things in order to infer that what Thaddaeus asserted about the absence of parallax was groundless or invalid. In reality the matter stood just so: that no trace whatever of parallax was present in this star, as we have abundantly demonstrated in Chapter Six [Capite Sexto]. But I wished only to warn that the things assumed for proving it from the given observations were, owing to an easily incurred error, less than secure; and not equal to the unraveling of so subtle a matter. For everywhere one must take pains to acquire such data as will not, by a slight error of one or another minute in altitude, or of a few [moments] in time, render the certainty of a hard-pressed matter precarious through some hallucination — lest there be any room left for those asserting the contrary to contradict. For it is not enough simply to have pronounced what is true, unless it is also evidently established that the thing is so and not otherwise; and this not for the sake of Truth itself, which by itself stands unmoved even if it is ignored by all, but for the sake of others who refuse to assent to it, so that, with their hesitations and obstacles removed, they may be compelled to believe the matter. I therefore wonder that Thaddaeus wished to entrust so arduous a business — and to confirm by superstructure a thing hitherto so incredible — to data so fluctuating and so liable to error, and which, from the least and scarcely perceptible deviations, would introduce the greatest distractions from the goal sought.

His demonstration is sufficiently neat and skillful, and detracts nothing from the laws of Geometry. But not everything that holds correctly in speculation about these matters can on that account be applied to practice without risk of aberration; for before that can be done, there is need of the service of the senses

and of certain aids — which, if they raise great structures upon the smallest [foundations], for the most part frustrate the effort.

He could surely have demonstrated this far more easily and more certainly from the star's maximum and minimum altitude in each position relative to the meridian — so that no room for hesitation would be left on account of one or another scruple wanting; nor would the time of transit across the meridian then need to be so precisely determined; and the difference of the two parallaxes, coming out as large as could be, would have laid the whole matter more fully open. But by a certain design of his own he entered upon this other path, although it was not sufficiently free from doubt — by which, granted he arrived where he wished, [and reached] the goal proposed...

whether he handled his proposal correctly. Yet I would not assert that he closed off all occasion for hesitation in the minds of others, sufficiently or more than sufficiently, nor that he persuaded them that the matter could not possibly be otherwise than he had stated, despite the arguments set out above.

Nor, indeed, does he adduce anything else by way of demonstration in that entire treatise, drawn from his own observations, that would more fully satisfy so difficult a question — as the grandeur of the proposed subject required. It is nevertheless enough that he noticed this: that this New Star [New Star of 1572] always kept the same distance from the polar star and from certain of the fixed stars [fixed stars] of Cassiopeia [Cassiopeia]. This could not occur in every position of the star, had it been subject to any parallax [parallax]. For although the distances he recorded are not entirely exact — as is clear from comparison with our own, drawn up earlier — this happened rather through a fault of the instrument, in that he often failed to sight along it correctly when repeating the measurement. But since he undoubtedly always found the same angle of the instrument, it is sufficiently proved that the distances were everywhere alike, even though the graduation marked on it was not measured with full precision, and so failed to detect the exact magnitude of the angle.

Not without reason, therefore, does Thaddaeus [Thaddaeus Hagecius (Hájek)] conclude that this Star admitted no parallax, and that it accordingly existed in the aether itself above the Sun — indeed in the starry sphere [sphaera Stellata] itself (about which, however, he hesitates somewhat). On this point in particular, had he ventured boldly enough to assert what is in fact the case, he would have had no cause for doubt; and our own findings support him. Had he been equipped with instruments for taking the altitudes and intervals of the stars with sufficient scrupulousness, there is no doubt that, in proportion to the great labor he

expended in the pursuit of truth, he would at least have pronounced that same truth — which he did establish — not, as he did, in a flawed form, but rather more evidently and beyond every handle for cavil, and would have carried more conviction.

He then digresses, in the same Chapter, against Andreas Nolthius [Andreas Nolthius], who by a nearly identical procedure had tried to prove that this Star was an elemental body — and rightly does he go out to meet him by means of Nolthius's own inept observations. But while he not unreasonably maintains that Nolthius's exact marking of the meridian line, and the star's altitude (which around this region does not increase very noticeably), render Nolthius's conclusions uncertain, there is a danger that these very impediments may also to some extent stand in the way of his own intention, by which he sought to build up an irrefutable certainty. Yet I do not doubt that Thaddaeus brought to bear far greater diligence in these matters, and far greater fitness of instrument, than Nolthius, since he produced results so admirably consonant with the truth — from which the other deviated very widely. This we shall make plain later, when we come to examine what Nolthius advanced.

In **Chapter Six** — which, however, he wholly cancelled in his revised *Dialexis* — Thaddaeus himself admits some of the things I have said in what precedes: namely, that if he had known both meridian altitudes of the Star, he could more easily have rendered judgment about its parallax — indeed not

only more easily, but much more evidently and surely, he would then have accomplished it. But as to why he did not employ the greatest altitude alongside the least, he gives no reason. I suppose that to measure the greatest with his instrument was not so convenient for him; otherwise nothing would have suited better.

In the same Chapter he also sets out, in a rather broad fashion, some matters concerning the aggregation and separation of parallaxes; and on that occasion he introduces the following two or three Chapters on the finding of parallaxes and of the distance from the Earth of those phenomena which sometimes pass beneath the Horizon and at other times stand above it. He then digresses into a general consideration of parallaxes, and intersperses a Table that works out the parallaxes up to the limit of 100 semidiameters [Semidiameters] of the Earth of remoteness, throughout a whole Quadrant — a Table that he afterwards enriched still further, by hundreds of semidiameters. And although this treatment of parallaxes is exceedingly useful, and although he proposes much in it learnedly and skillfully, nevertheless not everything everywhere stands consistent with his

own reasonings. Nor by this method will it be possible to elicit the parallax of any phenomenon, unless several requisites are at hand — as he himself proposed in those Chapters; which Thaddaeus too at length noticed well enough, partly by his own effort, partly admonished by others. He therefore, in his enriched *Recognition*, struck out most of it, added much more, and so — as in the Book transmitted to me — drew up twelve Chapters on the measurement of parallaxes in varying positions, and on their aggregation and separation, treating the remaining circumstances clearly and solidly, interspersing matters by which he greatly illuminates the Doctrine of parallaxes, and bringing all of it to completion there expeditiously and elegantly, clear of the rocks of error. Many of the Problems on these matters were devised both by himself and by that noble and outstanding Mathematician Thomas Digges [Thomas Digges] the Englishman, and by Paul Wittich [Paul Wittich]; and these, once devised, he polished and inserted, propounding them most learnedly and skillfully. There too he sets out, in a clearer and plainer form, several things that Digges had brought forward too intricately. As for what Thaddaeus very industriously and elegantly brought into the open in these Chapters concerning the unravelling of parallaxes, I am unwilling to deal with it at greater length here, since it is not our plan to treat parallaxes in general, nor to pursue their thorough investigation, except insofar as they must necessarily be brought to bear on the consideration of this phenomenon, with which we are dealing. For that would be too long-winded, and altogether foreign to our purpose. For even the things that Thaddaeus brings forward in a secondary way for the investigating and distinguishing of parallaxes are of such a kind, and so worked out to a nicety, that they have no need of my file.

One thing only out of all this I will add. Whatever is ingeniously contrived for investigating and disentangling parallaxes, by whatever method, if the phenomenon itself is presupposed to be set in motion by no motion of its own, but only to be subject to the universal revolution (as all those Problems are, which Thaddaeus adduces for this purpose), can in no way be accommodated to those phenomena which have a genuine course of their own. And therefore in the matter of comet-

parallaxes too, when these are to be investigated, such methods either offer nothing at all, or the very least of help — since comets are very rarely without some motion peculiar to them, and that motion, which they exert by their own force, sometimes exhausts the parallaxes, sometimes augments them, and now and then renders them, as regards such reckonings, utterly inscrutable.

Therefore the unravellings of parallaxes of that kind, contrived by whatever ingenuity, even if artful, are nonetheless of less utility.

Of this same kind, too, were all the Problems of Regiomontanus [Regiomontanus], and likewise those which Digges the Englishman and Wittich speculated upon in these matters — savoring more of sharpness of wit and of a remarkable readiness of invention than of any service in handling those phenomena of the heavens which exert some motion of their own, as we see happen in comets, to whose investigation they are chiefly directed, so as to accomplish what they aim at. If at some time a phenomenon similar to this New Star should arise — one that excludes every proper motion — then certainly the utility of such Problems is not idle, but in that case earns a foremost place. Some, however, will be of more, some of less, convenience. In other phenomena, which exert some course set apart from the primary motion, the application of such Problems is not merely too forced, but altogether discordant — as I have also admonished Thaddaeus of by letter. But leaving aside the windings of parallaxes, let us betake ourselves to the question of this Star's position in the heaven, which lies open to a plainer inquiry; and we shall examine in passing whatever Thaddaeus maintains on this point.

In **Chapter Ten** he teaches how to find the declination [declination] of some phenomenon, whether it has a parallax or not, and from its transit across the Meridian to ascertain its right ascension [right ascension] — or with what point of the heaven it culminates; and, given these two, to build up its longitude [longitude] and latitude [latitude] is not difficult. This too, referring it in his enriched *Dialexis* to Chapter 18, he carries out more copiously and more perfectly, so far at least as concerns the establishing of declinations, so that the apparent may be distinguished from the true, if any difference between them should arise. But since these matters partly have no place in the case of this Star, and are partly worn smooth and easy in themselves, I am unwilling to dwell on discussing them — especially since he there adds no example for this New Star, but defers it to the following Chapter. Therefore, leaving this aside, we shall tackle that one.

In **Chapter Eleven** he labors to investigate the place of the New Star in the Zodiac according to longitude and latitude; and this from the Time of its transit across the Meridian, together with the Altitude and therefore also the Declination given — where he revises, as less reliable, the things he had earlier written on this subject to Reisacher [Bartholomäus Reisacher], and hopes to set forth amended and more correct results. Concerning the things, then, which he noted in writing

to Reisacher, since he himself wishes them void, I shall add nothing — I shall examine at least those which he propounds in this Chapter. But because I find that, in his revised *Dialexis*, this matter has been in some part altered and augmented, I shall here transcribe the whole exactly as it stands there, where it is Number 19. For so, since it is not extant elsewhere, the rationale of the inquiry will more conveniently be at hand.

Chapter 19, an enriched version of Thaddaeus's *Dialexis*, which in the earlier one was the eleventh.

How the true place of the New Star in the Zodiac, according to longitude and latitude, is found.

It was demonstrated in Chapter V that this New Star excludes parallax altogether. Therefore its apparent place will be the same as its true place. But how it is to be found, we shall here prescribe three methods. The first two will teach how to find it from either one of the two: the meridian altitude of the Star, its true declination, and the point of the culmination of the heaven. The third will seek the same from the star's distance to its neighboring stars. The former of the prior methods I had already described earlier, to Bartholomäus Reisacher [Bartholomäus Reisacher], which he appended to his own Booklet; but it was there set out by me in passing, more truly than it had been written down, and demonstrated from the meridian altitude of the Star — not indeed an exact altitude, but one that could at the time be held, in the judgment of others, as close as possible to the truth. And although it does not stray very far from the truth, nevertheless, since I afterward wished to test the matter myself, with repeated trials by the Quadrant and observations of moderate magnitude, I found by careful diligence that the meridian altitude of the Star itself was

20 degrees 15 minutes. This Consideration was the last of all the others, on the 6th Day of May, in the Year 1573, at Hour 8, minute 29, after Midday — at which Time the plane of the Meridian coincided exactly with the plane of the Colure of the Equinoxes. The Sun, however, at the Meridian of Vienna [Vienna] on that Day and moment, stood, by the Stadius Ephemerides, in 25 degrees 16 minutes [of] Taurus [♉ Taurus]. That Altitude lay in the western [declining] part of the Meridian, toward sunset; the least altitude, which, subtracted from the Elevation of the Pole of Vienna, 48 degrees 22 minutes, leaves 28 degrees 7 minutes, namely the distance of the New Star from the Pole. Its double, 56 degrees 14 minutes, added to the least altitude, makes 76 degrees 29 minutes, the greatest Altitude of the Star. This could not be ascertained from observation on that Day. The remainder

of this, [taken] up to the Quadrant, indicates the distance of the Star from the Zenith of Vienna, 13 degrees 31 minutes.

Now, when the least Altitude of the Star is subtracted from the Elevation of the Pole, or this from the greatest Altitude, and the remainder is taken away from the Quadrant, the Declination of the Star comes out. Or again, when the least Altitude is taken from the greatest and the remainder bisected, and one of these [halves] is taken from the Quadrant, the said Declination emerges, namely 61 degrees 52 minutes [part. 61. min. 52.]. This same value is also found by adding the inclination of the Equator to the least Altitude of the Star. These things found and laid down, we shall arrive at the rest of what we have proposed for investigation, by the truest and most evident principles of Mathematics, through the following deduction.

Diagram. A spherical-triangle figure illustrating the Colure of the Summer Solstice and the determination of the New Star's position. The figure is a curvilinear (spherical) construction in the lower-right of the page; the accompanying explanatory text reads:

Let there be, in the subjoined diagram, the arcs of the Colure of the Summer Solstice CAGK, in which let C be the Pole of the Zodiac, A the Pole of the World [Universe]. Let GED be the arc of the Ecliptic; KD the arc of the Equator; D the point of the Vernal Equinox. Let ABD be the arc of the Meridian Circle, which coincides with the Colure of the Equinoxes itself. Let CBE be the arc of the Great Circle drawn from the Pole of the Zodiac through the Center of the Star B, when it was on the Meridian — [meeting] with that Vernal section, or Colure of the Equinoxes. The Declination of the Star, DB, is known. Therefore BA also will be known.

- C (upper area, near the apex): Pole of the Zodiac [Polus Zodiaci]
- A (just below and left of C): Pole of the World [Polus Mundi]
- B (right side, mid-figure): Center of the Star [Centrum Stellae]
- G (lower left): endpoint of the Ecliptic arc GED
- E (lower right, near D): point on the Ecliptic / Equator arcs
- D (far lower right): point of the Vernal Equinox [Punctum Aequinoctii Verni]
- K (lower left, below G): endpoint of the Equator arc KD and Colure arc

the remainder, that is, up to a quadrant. But AC is not unknown either, being the distance of the world's pole from the pole of the zodiac, which always equals the magnitude of the maximum declination of the Sun, 23 degrees 28 minutes.

From this too the complement of that arc AG becomes known, which measures the angle BDE: 66 degrees 32 minutes. I claim, then, that two things are likewise given — the longitude and latitude of the star — namely, the two sides ED and EB of triangle EBD.

Since C is the pole of circle GED, the arcs CE and CG will be quadrants of the greatest circles; likewise, since A is the pole of circle KD, the arcs AD and AK will also be quadrants of those circles. Again, since arc CE passes through the poles of GED itself, it cuts that circle at right angles, by Regiomontanus, *On Triangles* III.17, and by Theodosius I.20; and the angles at E will be right. And once more, since GED is a great circle, it cuts circle CBE at right angles. It therefore passes through the poles of that circle. We have, then, the right triangle BED, in which the side BD is known — namely, the declination of the star — and the angle BDE is known. Therefore, by Regiomontanus, *On Triangles* IV.34, or by Copernicus III, the remaining sides will be given — namely BE, the latitude of the star, 53 degrees 59 minutes, and ED, the longitude of the same, 36 degrees 41 minutes, reckoning the start of the count from the vernal equinox. That is, the star lies in 6 degrees 41 minutes of the dodecatemory of Taurus [♉], which is what we set out at the start to investigate.

In this way, then, Hájek reasoned about the place of this star with respect to the ecliptic — and, indeed, not unreasonably, if the observational data themselves had been established exactly enough, free of every entanglement of doubt.

Here, however, he calls upon the same observation as evidence — the one regarding the meridian transit below the pole, which he had earlier used in his investigation of parallaxes. That is, on 6 May of the year 1573, at 8 hours 29 minutes, when he supposed the star, together with the plane of the colure of the equinoxes, to have occupied the meridian precisely.

But concerning the *time* of this transit, the first question is how he arrived at it without any error. If by clocks, he accomplished nothing; for the indication even of the most finely wrought of them is unreliable, as we explained in part, with the reasons, in Chapter Two — why this happens. If he attempted to provide this more precisely by the altitude of some fixed star, he nonetheless slipped easily into error. For neither the places of the fixed stars, nor even the motions of the Sun itself, were so reliably established for him from any tables that he could be sufficiently certain about deriving one or two minutes of time from this — not to mention that the very instrument with which he took the altitudes did not afford precision within five minutes. I say nothing of the fact that, in such a position, the stars could have been so placed that an error of three or four minutes in altitude

varies the time by a few seconds. There is also this further point: even if the observation had been carried out accurately enough, and the corrected place of the Sun and of the assumed star were ready to hand, even so the moment of time is not known so scrupulously, nor is there need for such precision in this practical procedure. For the altitude of the stars changes more slowly than the revolution of the equator, which measures time. And so, from the fact that it is less,

it is inferred to be more, incompetently and not without some suspicion of error. And the nearer the stars are to the meridian, the slower is the change of altitude; whereas near the horizon, even though that change proceeds more rapidly and somehow serves the matter more readily, nonetheless, because of the impediments of the refractions insinuating themselves there, the stars appear somewhat higher than they truly are, and so frustrate any more exact precision. By a fixed star, then, on this account, it was not possible to attain the very moment of time; for here a broad investigation does not suffice to carry the matter through. Rather, since an aberration of one minute in time shifts the right ascension of the star by a quarter of a degree, one must be made certain to within ten seconds at the least, if we wish to have the place of the star determined to within about two or three minutes.

Likewise, in the determination of the meridian line there lurks no slight ambiguity. For by the Sun it is not designated so precisely that it satisfies the minutes of azimuth, nor by the stars either — except by the help of certain circumpolar stars, a method which, so far as I know, has been thoroughly examined by no one else hitherto, as will become apparent when (God willing) the opportunity to treat of these matters is given in the *Mechanics of Restored Astronomy*. But although a slight aberration in the meridian line could have varied the latitude of the star imperceptibly, since at that point it varies most slowly, nonetheless, as regards the right ascension, it commits nearly as great a deviation in it as the number of azimuthal minutes by which one departs short of or beyond the meridian point.

But grant that all this was carried out by Hájek so correctly and circumspectly that not a single scruple lies hidden: even so, this star did not cross the meridian precisely together with the colure of the equinoxes. From these data, even taking the same place of the Sun he uses, this will not hold — much less if it is corrected and applied in agreement with the heaven itself. And therefore his demonstration will not indicate the position of the star so exactly as he supposes; indeed, since the colure of the equinoxes is not joined precisely to the meridian,

this whole inductive route will not bring the matter out to the nail [i.e., to perfection].

But lest anyone suppose that we put these things forward without cause, we will now prove this very point both from his own assumed place of the Sun and from our own corrected one.

He applied the motion of the Sun, which he cites from the *Stadius Ephemerides*, to the meridian of Vienna correctly enough, placing it at 25 degrees 16 minutes of Taurus [♉]. But since the right ascension of this point is 52 degrees 55 minutes, and the 8 hours together with 29 minutes make up 127 degrees 15 minutes of the equator, when these are summed together the right ascension of the mid-heaven for that moment of time will come out to 180 degrees 10 minutes. The colure of the equinoxes therefore exceeded the meridian by a sixth part of a degree, and the right ascension of the New Star will come out to 0 degrees 10 minutes — also a sixth part of a degree further on than that which follows from Hájek's induction; and

although this discrepancy is not so very great, nonetheless I do not suppose that he wished to inquire into the place of the star here in so broad a manner as to be content with prescribing limits for it within a sixth part of a degree. For in that case there would have been no need of this subtle investigation and demonstration, but it would have been possible to reach so broad a designation from the globe alone. Moreover, Hájek himself asserts that the plane of the solstitial colure was at that time exactly conjoined with the meridian.

If we apply here the truer place of the Sun, just as it was demonstrated by us in Chapter One from the least doubtful observations, the matter will be carried into a still greater divergence — one which, however, comes nearer to the very right ascension of the star (whether or not Hájek thinks so). For from the *Ephemeris* of the Sun for the year 1573, scrupulously set forth in Chapter One in its place from our tables, the place of the Sun for 8 hours 29 minutes will stand at 25 degrees 33½ minutes of Taurus [♉]. If a half-minute is neglected on account of the difference of meridians, the right ascension of that place is likewise, by our own Canon in the same chapter, computed at 53 degrees 12 minutes — taking the maximum obliquity of the ecliptic at the true value found by us — adding here again, as before, for the 8 hours 29 minutes the 127 degrees 15 minutes; the right ascension of the mid-heaven together with the New Star will come out to 0 degrees 27 minutes, which agrees exceedingly well with the value we found in Chapter Five, so that scarcely a difference of one minute falls between them. And so Hájek, without himself knowing it, hit upon the truest right ascension of the

star through that time of culmination — yet by accident rather than because by that procedure he aimed at the target so precisely. This may readily be granted.

According to this truer reasoning, then, the colure of the equinoxes was removed from the meridian by half a degree, less at least three scruples. By no means, therefore, did it coincide with it; and consequently, by such a diagram and tenor of demonstration as Hájek used, the exact place of the star is not readily reached, if everything required is to be carried out with due precision.

He gathers the longitude of the star to be 6 degrees 51 minutes of Taurus [♉], where it falls short of its very place by at least three scruples; and he infers the latitude to be 53 degrees 55 minutes, exceeding by a sixth part of a degree. And this is according to the earlier *Dialexis*; for the values which I cited from the later one stand somewhat differently. There, from the same data, he reckons the longitude of the star at 36 degrees 41 minutes of Taurus [♉], with a latitude of 53 degrees 59 minutes — which is inferred more agreeably from the course of the operation. And here, as regards the longitude, it falls short of the true value by 13 scruples, with the latitude exceeding by 14 scruples, as we show. If, according to the truer right ascension, which follows from Hájek's data, the result is 0 degrees 10 minutes,

and taking the same place of the Sun, and the maximum declination commonly used, 23 degrees 28 minutes — the same declination which it supposes — we inquire into the longitude and latitude of the star from the diagram, in the way we used in Chapter Five in a closely similar matter, everything will come out as follows.

Diagram. A spherical-triangle figure inscribed in a circle, used for the longitude/latitude derivation. The bounding circle carries the labels B and C near the top, G on the upper left, F at the left, D on the right, and E at the lower right. Within the circle, several arcs cross; A is marked near the center-top, with H, K, and I marked along a horizontal arc in the lower-middle region. The construction shows the right triangle BCA used in the accompanying table of sides and angles.

- B (top center): vertex on the circle
- C (top, just right of B): vertex on the circle
- G (upper left, on the circle): point
- F (far left, on the circle): point
- A (center-upper, interior): vertex
- H (lower-middle interior): intersection point
- K (lower-middle interior, right of H): intersection point

- I (below H/K, interior): point
- D (right, on the circle): point
- E (lower right, on the circle): point

Element		P		M.	Description
Side [Latus]	B	2	28		Distance of the poles, commonly used [Distant: Polorū usitata]
	C	3			
Side [Latus]	B	2	7		Complement of the declination [Compl. Declinationis]
	A	8			
Angle [Angulus]	C	9	10		Right ascension added to 90 [Asc. R. ad 90 addita]
	B	0			
	A				
Hence latitude [Hinc Lat.]	C	3	2½		Complement of the latitude [Compl. Latitudinis]
	A	6			
Angle [Angulus]	B	5	12		Distance of the New Star from [the start of] Cancer [Remotio Novae St. à ☊]
	C	3	½		
	A				

Subtracting, then, the angle BCA from the beginning of Cancer [☊], the longitude of the star comes out at about 6 degrees 48 minutes of Taurus [♉] — which falls short of our finding by about six scruples — with the latitude, derived from the complement CA, standing at 53 degrees 57 minutes, exceeding by a fifth part of a degree.

But examining in the same way, by our own restoration of the Sun's motion, the right ascension that came out as 0 degrees 27 minutes, and applying also the truer maximum obliquity, 23 degrees 31½ minutes, while keeping the same declination, these will come out as follows.

Element		P		M.	Description
Side [Latus]	B	2	31		Distance of the poles from our own observations [Distantia Polorum ex proprijs Observat.]
	C	3	½		
Side [Latus]	B	2	7		Complement of Hájek's declination [Complementum Declinationis Thaddæi]
	A	8			
Angle [Angulus]	C	9	27		Right ascension, 90 from [the

Element	P	M.	Description
	B	0	start of Aries] [Ascensio 90 à ♈]
	A		
Hence latitude [Hinc Lat.]	C	3 10	
	A	6 ½	
Angle [Angulus]	B	5 59	about [feré]
	C	2	
	A		

And so, according to this reckoning, the longitude of the star falls at 7 degrees 1 minute of Taurus [♉], with a latitude of 53 degrees 49½ minutes. That the longitude exceeds the truer position by about seven scruples happens not through any fault of the right ascension, which holds well enough, but because the declination according to Hájek exceeds by six scruples, from which the latitude too turns out somewhat greater than it should. And let this much, regarding what he brings forward in Chapter Eleven concerning the establishment of the longitude and latitude of this star, suffice as our inquiry.

In the following Chapter Twelve, under the form of another diagram, he likewise finds the same result from the same presuppositions, but by a somewhat more convoluted induction. But because there too he joins the right ascension of the star to the colure of the equinoxes — which, from the very data, cannot hold, especially once the truer place of the Sun is applied, as we have already shown — there is therefore no need to go over these matters again so painstakingly, since not even Hájek himself [has the angles and sides of that diagram]...

resolves it into numbers, content with the values he had deduced by the earlier method, and these come out here in like manner, provided everything had been done correctly.

In **Chapter Thirteen** he finally attempts to derive the same result from the distance of the New Star to its neighbors in Cassiopeia, on the assumption that the positions of those neighbors are known — an investigation far safer than the previous ones, since here no account is taken of the transit across the meridian or of the declination, but only the distance from two fixed stars, which is subject to more reliable measurement. The one difficulty that remains is that the positions of the fixed stars had not previously been restored to the standard of the heavens, and that the distances measured with the radius [cross-staff, *radius*] are not entirely free of error. For here Hájek [Thaddaeus Hagecius] adopted the positions

of the fixed stars just as the Copernican calculation supplies them — that is, by how much they deflect from the heaven in those same stars he uses, namely the Bright Star of the Throne [Lucida Cathedrae] and the one beside the Bend [Flexura], number 4 — as is clear from comparison with our own verification set out in Chapter Five. Hájek uses an inductive method of demonstration much like the one we used in this same undertaking, and from it he deduces the longitude of this star as $6^{\circ} 54'$ Taurus. The latitude he makes $53^{\circ} 49'$. Here he has the longitude precisely the same as the one we have repeatedly found by experience; in latitude he is over by only four minutes [*scrupula*]. But this agreement was rather accidental than a proof that everything had been carried out correctly. For neither were the distances exact, nor were the positions of the fixed stars; and so, with one error correcting another by chance — which can sometimes happen — an agreement of this kind came about. For in the later revision of the *Dialexis* as well, with the New Star's intervals from the said fixed stars limited somewhat differently — intervals that also agree more closely with ours — Hájek found this star's position to be somewhat different, namely at $6^{\circ} 47'$ Taurus, with a latitude of $53^{\circ} 59'$. These recede further from our determination, namely by 7 minutes [*scrupula*] in longitude and by 14 minutes in latitude, even though they rest on more correct distances. But since the positions of the fixed stars he applies are uncorrected, the intervals — even if they were in every way correct (and on this point too something is still wanting as regards the final refinement) — do not bring him to the intended goal.

But concerning the position of this New Star as established and examined by Hájek, let this suffice. With it we also conclude those matters that bear on the astronomical consideration of the star, so far as they could be drawn from his own opinions.

He does indeed have some other remarks about this very star, scattered here and there in his *Apologetic Writings* and in his subsequently published works on comets; but these are for the most part consistent with what he treated here in the *Dialexis*. If anything peculiar has occurred in them that deserves comment, I shall examine it — whatever it may be — when I work through the writings of those against whom he argues.

In **Chapters Fourteen and Fifteen** he treats of the astrological significations of this star, into which he also mixes certain theological matters. But since I have resolved to embrace in this Book only what can be set out mathematically about this star — and since I am not minded to deal now with astrological prognostications, though I know they are eagerly sought after by most people — I

do not wish to add anything to what Hájek has brought forward plausibly and piously enough about this subject, with a probable conjecture besides; rather, I leave these matters at their own value, since all the foregoing chapters were to be devoted to such investigation, and I rest content here. As for those astrological points, I shall indicate some of them in general terms, according to my own judgment, in the Conclusion of this Book — and perhaps I shall bring forward something more fully in the Epilogue of the whole work.

He then adds a certain appendix against Raimundus the Italian [Raimundus Italus] and Theodorus Graminaeus [Theodore Graminaeus], in which he criticizes their inept and foolish opinions. About these too I shall say nothing here; but when I weigh their own writings, I shall set out briefly what I think of them, since they scarcely deserve a long and more careful consideration.

Afterward he appends the descriptions of this star by certain others, such as those of Paul Fabricius [Paul Fabricius] and Cornelius Gemma; and he also added to that *Dialexis* of his still more material — drawing further on several things excerpted from a certain little book about this star published some time ago. But I myself long since advised him by letter to leave these things out, since I had determined to revise this material and to treat it more fully. And I hope I have accomplished just this in the present Book, so that what was previously found wanting is now restored and completed abundantly and to spare.

Hájek also appended the views of Johannes Regiomontanus [Regiomontanus] and Vögelin [Georg Vögelin] concerning two ancient comets, on the question of where these are to be placed; these I shall discuss elsewhere.

And since he attaches Fabricius's writing on this star directly after his own, I too shall give the place next to his to the examination and weighing of this material.

D. Paul Fabricius, Mathematician and Physician to the Emperor [D. Pavlṽs Fabricivs Mathematicus & Medicus Caesarevs]

That most learned and outstanding man, Paul Fabricius, wrote certain pages — not very many — about this star, which he presented to the Archdukes of Austria; unless perhaps more was worked out by him on this subject than what Hájek attached to his *Dialexis*, and than what we have so far been permitted to see.

In those few small pages, however, he touched only very sparingly on the matters that serve to dig out the core of the question more deeply. Nor did he, with his

own remarkable learning, devote effort worthy of the magnitude of the matter — perhaps he was not even up to it himself (possibly on account of the poor health he was then struggling with) — much less make others believe that he had given satisfaction in so great an undertaking. But whatever his statements may amount to, we shall now look them over.

He says this New Star first appeared at the end of October in the year 1572; but I judge that he reports this on the strength of some rather uncertain rumor, rather than on anything that is established for certain — namely, that it was observed by anyone before the beginning of November.

He attributes to it a magnitude greater, from the outset, than the star Sirius [Syrius], and makes it a rival of Sirius in color too; he then says it gradually diminished and changed from white to a more reddish hue. In these points he agrees well enough with what we set out by way of general account in the Third Chapter.

He fixes its longitude at $6^{\circ} 14'$ Taurus, with a latitude of $1^{\circ} 54' 12''$ [recte: 54° ?] — where in longitude it falls short of its true position by almost a whole degree, and in latitude it is over by almost half a degree. This is surely far too great a departure for the industry of so great a mathematician. Nor does he sufficiently indicate, much less demonstrate, how he arrived at knowledge of a position of this kind. Yet it is the mathematician's task not merely to assert, but also to demonstrate.

He also asserts that this star remained fixed and admitted no change of position. And indeed it truly remained fixed perpetually in the same place.

Next, intending to investigate its parallax, he gets through the matter too hastily and in too broad a manner. He says that, whether on the meridian above and below, or when it was most strongly displaced from here along its sides, it always kept the same distance from the fixed stars — though he does not add what that distance was. He merely alleges the testimonies of others, whom he does not even name, and from this he rightly infers that the parallax of this star was either nil or wholly imperceptible. But he does not establish this by indubitable proofs, nor (as would have been fitting) does he carry conviction — perhaps because he was too intent on brevity.

He rightly concludes that it was not in the elementary region, nor in the lowest aether near the Moon, but in the sphere of the fixed stars, or at the least not below the orb of Jupiter — which he asserts to be a marvel (as indeed it was). For

my own part, I have already argued more than amply above that it is altogether to be placed among the fixed stars.

He then makes a distinction between this star and comets, which he supposes — on the Aristotelian doctrine — to blaze lower down; and therefore the things he brings forward about them are not all correctly established. He does, however, declare not inappropriately that this star differed from comets in its stillness, its lack of any tail [Crinium carentia], the purity of its light, and its non-twinkling [Scintillatione].

He truly affirms that it was exceedingly great and surpassed the bulk of the Earth, though he does not make clear in what multiple proportion this was so.

Finally, he had asserted that it was no planet, since all the others — and Mercury [☿] itself among them, which is more rarely seen — were observed in their due places at about that time. He also mixes in here some remarks about an observation of Mercury, and asserts that its position agrees well with the Copernican calculation. That this can sometimes happen, I shall grant; but not always — indeed rather rarely, for Mercury [☿] is a manifold star, as observation has taught me; yet for the most part the goal is more nearly attained according to Copernicus than the Alphonsine reckoning gives it. But all this lies outside the matter proposed, and no one (I think) could have supposed that any of the planets had quit the zodiac and migrated northward into the tents of Cassiopeia.

Lastly he disputes whether it is permissible to call this star a comet or not, and on this point he remains in doubt. Here he understands under the word "comet," as he says, other kinds of blazing globes as well. But since this star had very few features in common with comets, while most — indeed all — were consistent with the fixed stars themselves, he inclines to the view that it should rather be assigned to the condition of a star. And although he pronounces on this far too timidly, it is nevertheless truer than he himself perhaps had thought — except that this star did not last perpetually, as the others do, and altered in turn its magnitude and color, in which two respects it was unlike the fixed stars.

And these are more or less the things that Fabricius brought forward about this star. Since in themselves they are few and slight, they do not call for any fuller examination. For what he afterward appends about its effects, to report and pass judgment on it is foreign to my purpose. So, setting these things aside, I shall turn to Bartholomaeus Reisacherus [Bartholomäus Reisacher], pausing a little among the Austrian mathematicians before I betake myself elsewhere.

D. Bartholomäus Reisacher, Professor of Mathematics at Vienna in Austria [D. Bartholomaeus Reisacherus Professor Mathematicum Vienna Austriae]

That most distinguished and learned man, Bartholomaeus Reisacherus, professor of mathematics at the Gymnasium of Vienna, wrote a little more clearly and fully about this marvelous and most splendid new star. First he has some general remarks about its form, magnitude, position, and color, very nearly in agreement with what we ourselves brought forward on these heads. He then recites the various opinions of those who held it to be either elementary or aethereal, or augmented by the interposition of vapors or some other medium, or of the class of comets, or even none of these; and he reports similar disputations of various talents, and argues over them in different ways. But since I have resolved to examine the opinions of others separately, and as it were to test them on the touchstone [Lydium lapidem, lit. "Lydian stone"] of truth — calling to the balance most of the things that Reisacherus records — I do not wish to linger here in weighing them.

Although he does indeed say that from the start he had agreed with those who held this star not to be a new star at all, but rather one of the old ones — namely the eleventh star of Cassiopeia — which, because of the intervention of some vapor or other intervening transparent body, had been rendered more luminous; and that from the beginning he had been unable to distinguish that eleventh star from the New Star, since the latter, being faint, was overwhelmed by the brilliance of this one's light: nevertheless he afterward changed his opinion and pronounced a sounder verdict, once the eleventh star became more readily visible on its own.

At last, having weighed back and forth all the arguments that could be brought for one side or the other, he took refuge in parallaxes as his arbiters. From the fact that this star, with respect to the stars of Cassiopeia — with which it formed a square [Tetragonum] — kept a constant distance from them, both near the zenith at its greatest altitude on the meridian and near the horizon at its lowest, he concludes that it can by no means have had its place in the elementary region. He adds a geometrical demonstration showing how evident the discrepancy would be between the position of the object seen in the lower situation and the position seen by one in the upper situation — so much so that the difference would here turn out roughly twice as great as there. This he sets out in a fairly broad way, and although the course of his demonstration is not without merit, he does not

add what the distances of this star from the fixed stars of Cassiopeia were. He simply reports that they were similar in both situations — which someone else could just as easily deny, especially since he does not say how great they were. So too he does not absolutely determine the magnitude of the parallaxes that would arise, on the assumption of some distance from the Earth, in the high and in the low situation — the two things I look for in this course of his demonstration. Nevertheless he infers from this, not ineptly, that the star was in no way in the elementary region, but rather, by far, that it was aethereal.

Afterward he examines the observations of one Busch, a certain painter and citizen of Erfurt who took an interest in these matters (of whom I shall speak in the proper place), and he mixes in with them certain other things partly theological, partly physical, according to the views of various authors.

Finally he gives his own verdict, in which he judges that this star should be assigned a celestial place, not an elementary one. As for what kind of material it was made of, and how it came to exist there, he commits this to the hidden counsel of God, for whom nothing is impossible — or else to the philosophers and to the intelligence of each individual sphere. If, however, some physical cause had to be brought forward, he prefers to approve this one along with the Pythagoreans: holding that the star was among the other stars in the eighth sphere [Sphaera octava], but that on account of certain impediments it had lain hidden, until, those impediments being removed, it was at last revealed. And this view, he thinks, can be confirmed from Aristotle's opinion concerning the nature of the Milky Way [via lactea]; and that it could even be that this was the very same star which Cyprianus Leovitius [Cyprian Leowitz] records as having stood fixed, also next to Cassiopeia, in the year 1264. Thus he does not altogether reject the opinion of those who hold that it is indeed not new, but shows itself from time to time at intervals. Yet he does not put all this forward as a flat assertion, but leaves it for others to judge, or even to refute. And in that he did rightly. For such things are not

of such a kind as to deserve any settled certainty, at least so far as physical consideration is concerned (about the rest — theological and metaphysical — I do not now dispute). For the Pythagoreans' opinion cannot stand in any way, nor was this star an old one rendered brighter through the interposition of some other transparent body, as I shall inquire elsewhere; nor was it even the same as the one which Leovitius mentions. For where was it hiding for those 360 years? If by ascents and descents, or by the interposition and withdrawal of some intervening medium, this could have happened, why did it not appear earlier as

well — why, in the same way, did it not show itself over so many ages of the world that had passed, and then again vanish? Why has the same not happened more often in certain other stars? Why has such an illumination, brought about by some intervening medium, not now and then occurred in stars genuinely coeval with the world, even in those that lie along the Galaxy [Galaxiam]? But let these matters pass; they scarcely deserve laborious refutation. Nor, moreover, is it certain regarding that star which Cyprianus adduces, whether it was really so. For there is no mention of it in any other histories, nor does he himself cite any sure author, but he says only that he had it from a manuscript codex. But suppose it were so — does it therefore follow of necessity that this star was the same as that one, as though more stars could not be produced in the same way? For if some comet similar to another were seen many years before, around the same place too, shall we therefore say that it was the same as the earlier one, and that meanwhile it lay hidden I-know-not-where — as though that cause, from which such accessory phenomena arise, were so barren that it could shape nothing but one or another, or a few, of this kind? But let these things too be set aside as of no great importance, and let us proceed to what he brings forward about the establishment of this star's location.

He says that he observed its lowest altitude at Vienna to be for the most part 20 degrees, sometimes greater by five or ten minutes. It is clear, then, what sort of instrument he used, since he could not distinguish five or ten minutes. Yet he inclines more to this — that it was elevated ten minutes above twenty degrees — and in this matter he is not far wrong, for he makes it at least a single minute higher than is right. For taking the altitude of the pole at Vienna as $48^{\circ} 22'$, just as Peurbach [Purbachius] and Regiomontanus marked it down — which Reisacher [Reisacherus] also uses as beyond doubt — I say that the New Star had there its lowest altitude of $20^{\circ} 9'$. For it was distant from the pole by $28^{\circ} 13'$. And these figures agree tolerably well with that altitude of Reisacher's which he asserts to be elevated a sixth part beyond twenty degrees [i.e. $20^{\circ} 10'$]; indeed they square more correctly than the annotation of Thaddaeus [Thaddaeus Hagecius] indicated above, which makes it elevated a fourth part beyond 20° [i.e. $20^{\circ} 15'$], and on that account makes the declination greater than is right by six minutes. Although to define these things very precisely is impossible — unless at least the observed altitudes of the star were exactly consistent, and the elevation of the pole itself were also examined with sufficient care. Reisacher does indeed use this very polar altitude which Regiomontanus put forward; but I am surprised that neither he, nor any others that I know of, among so many distinguished

mathematicians whom the Viennese Academy continually possessed, made trial of this matter. Is it really fitting that we should be so slavishly bound to the assertions of others as to attempt nothing in these matters ourselves? It may be that those older astronomers investigated this elevation of the pole by means of the solstitial Sun, and if so, they could scarcely have produced a precise figure. For they did not take account of parallax; or, if they did so, they certainly did not guard against refraction, which occurs at the winter [Brumali] declension of the Sun. And if they worked in places of intermediate solstices, they fell still further short of the mark, on account of the motion of the Sun not being rightly understood.

It would therefore have been fitting for Reisacher first to have examined the Viennese pole from the circumpolar stars, before he put forward any settled certainty about this New Star — had he indeed attempted it carefully.

Furthermore, as for the longitude of this star according to the earlier positions of Thaddaeus written out for him, which he appends at the end, he says it was $6^{\circ} 24' 8''$ [Taurus], where it falls half a degree short of the mark, and the latitude $53^{\circ} 49'$, which is in excess by at least four minutes. But Thaddaeus, appending this writing of Reisacher's to a repetition of his own *Dialexis*, limited these figures somewhat differently, so that the longitude is $6^{\circ} 41' 8''$ and the latitude 54° , falling short by only a single minute. Here indeed in longitude he comes nearer to the true value — being now only 13 minutes in advance — yet in latitude he deviates more than before, committing an excess of nearly a fourth part of a degree.

Then for that little star of the fourth magnitude which is the eleventh in number, near which the New Star lay, he compares its place; and from the position of the star according to Copernicus he gathers the meridian altitude at Vienna as $19^{\circ} 0' 2''$, where, on account of the position of the fixed star not being rightly verified, it has seven minutes more than is right. For the declination of this star, in the place where we have restored it, was according to our restitution $60^{\circ} 34'$; the complement of this, which measures the distance from the pole, is $29^{\circ} 26'$; this, subtracted from the altitude of the Viennese pole, leaves as remainder the lowest meridian altitude of the star, $18^{\circ} 56'$. He then subtracts the meridian altitude of the star from the altitude of the comet, and by his reasoning gathers it to be $1^{\circ} 8'$; whereas by the truer method, according to what was said before, it would be $1^{\circ} 13'$ — which comes nearer to the distance of the New Star from the said little star, which he says he observed by the radius [Radium] to be $1^{\circ} 25'$,

reported with the aid of Peurbach's Gnomonic Table [Gnomonica Tabula]; and thus he constricts the interval too much, by six minutes. But to what end is all

this, and to what use? Was the place of the New Star to be examined by the distance taken from the difference of altitude of the stars, as he wished to do? For he sets these things out far too confusedly, so that it is scarcely possible to make out what he means to say. If they had obtained the meridian at the same time, both the New Star and the eleventh, then perhaps something of this kind could be drawn from it; but in fact, when the New Star was crossing the meridian, the other was absent by nearly two degrees, falling short by at least six minutes — so that it is no wonder if he did not match the difference of altitudes to the distance itself.

But since these matters serve no particular use, let us pass them by.

He afterward rightly censures those who set the latitude of the star at no less than 50 degrees, and likewise censures, not undeservedly, the claim put forward by Cyprianus Leovitius that the star itself had moved three degrees toward the north [Boreas] — for it never moved from its place at all, since it perpetually displayed the same meridian altitude, as he duly maintained.

Finally, having concluded the astronomical and physical consideration, he adds an astrological prognostication, which I willingly pass over.

Now, since I find no other observers or describers of this star in Austria, let me turn my course toward Swabia [Sueviam], crossing the Danube, and to Augsburg of the Vindelici [Augustam Vindelicorum], set on the borders of Swabia and Bavaria interposed between them; let me betake myself there to inspect what my old friend (of good memory) the Consul Paulus Hainzelius [Paul Hainzel] set down in writing about this phenomenon.

Dn. Paulus Hainzelius, Consul of Augsburg

Although in the Fourth Chapter [Capite Quarto] I sufficiently set out the observations made on this New Star by the most distinguished and most learned man, Dr. Paulus Hainzelius, Consul and patrician in the renowned Republic of Augsburg of the Vindelici — by means of the very large quadrant which I built in his garden while I was staying there — I nonetheless added there nothing of those matters concerning this star which had been committed to writing by the Consul himself. This I deliberately deferred to the present place, so that I might be able to call them up separately and more fully under their own consideration.

Hainzelius wrote no particular treatise about this star (so far as I know), but at least some letters to that most erudite and excellent man Hieronymus Wolphius [Hieronymus Wolf], schoolmaster [Gymnasiarcham] of that same city, who

studiously cultivated and propagated both Greek and Latin letters — and who likewise, in his late old age some years ago, fell asleep, about the same time at which both the Hainzel brothers departed, not without grave loss to their commonwealth.

That letter, then, which the same Consul wrote on this account to the said Wolphius, was afterward communicated to me — which I shall set down here, so that it may become more widely known what the judgment and opinion of that excellent Hainzelius was concerning this star. But since the letters sent to Hieronymus Wolphius by that most distinguished man, and one who deserved excellently of literature, Dr. Caspar Peucerus [Caspar Peucer], at that time chief professor at Wittenberg, gave occasion to these Hainzelian letters — letters of which he himself also makes mention, once and again, in his own letters to Wolphius — it seems more fitting that I first set forth a copy of Peucer's letter to Wolphius, which ran as follows.

A Specimen of the Letter of the Most Distinguished and Excellent Gentleman, Caspar Peucer, to Hieronymus Wolf, which Gave Occasion to Hainzel's Writing

Exemplum Literarum Clarissimi et Praestantissimi Viri D. Caspari Peuceri ad Hieronymum Wolphium, quae Hainzelianae Scriptioni ansam praebuerunt.

To the Most Distinguished Man, Renowned for Learning and Virtue, Lord Hieronymus Wolf [Hieronymus Wolf], Rector of the Public Schools in the Famous City of Augsburg [Augsburg], his esteemed friend.

Greetings.

I hope you have received the letter I lately wrote you in reply. What prompted me to send it was the new and unusual star which we see standing fixed in one place beneath the constellation Cassiopeia [Cassiopeia], in its fourth division. In its light it resembles a star, but in purity of light, brightness, sparkling, and magnitude it shines more brilliantly than all the others, both planets and fixed stars alike, Venus excepted. It twinkles — which is an argument for great altitude and distance — and is far from the planets; and from its very position outside the zodiac, since it is set apart by no proper motion of its own but is carried round solely by the primary motion, it stands like a fixed star. Yet it cannot be counted among the fixed stars unless we declare it to be a New Star, since in this region of the sky no such thing has ever been seen in any age.

We have investigated its motion and position with astronomical instruments, observing carefully, and we have found the place it occupies to fall in the sixth degree of Taurus [♉]; and that at most, when it reaches the summit of the heavens, it is distant from the zenith by no more than 10 degrees 4 minutes, and that it never comes nearer the horizon than an interval of 23 degrees 33 minutes. But upon comparing all the observations together, we have found no difference between its true and apparent place, and therefore we find no parallax at all. We judge it to be a comet, and we would affirm this for certain if its altitude were established by careful observation. Since in the brightness of its light and in its appearance it resembles Jupiter, we conjecture that it was kindled from Jupiter; and since about two days ago it began to advance with a changed course, we shall observe whether this body will continue thereafter with a proper motion of its own. I judge that something altogether fateful is portended to this latter age. Since you too examine the heavens diligently, and such portents are of the greatest concern to our friend Cyprian [Caspar Peucer's associate Cyprian — likely Cyprianus Leovitius], I earnestly beg you to write to me whatever you have ascertained and investigated. Farewell, and may all go happily with you. 7 December, in the year 1572.

Caspar Peucer [Caspar Peucer].

In this manner the learned Peucer [Caspar Peucer] wrote to Hieronymus Wolf [Hieronymus Wolf]. When this letter had been communicated through Wolf to Consul Hainzel [Paul Hainzel] — since Peucer knew that Hainzel took particular delight in such matters and had diligently devoted himself to observing the star with his great quadrant — Hainzel replied to Wolf in the following manner, and offered his own opinion, both about the New Star [New Star of 1572] and about certain things contained in this letter of Peucer's.

Here Follows a Specimen of the Letter of the Most Eminent and Distinguished Gentleman, Paul Hainzel, Patrician and Consul of Augsburg, to Hieronymus Wolf

Sequitur Exemplar Literarum Amplissimi et Spectatissimi Viri Pauli Hainzelii Patricij et Consulis Augustani ad Hieronymum Wolphium.

To the Most Learned Man, Lord Hieronymus Wolf [Hieronymus Wolf], his dearest friend.

Greetings.

The letter that you gave me to read — the one written to you about the New Light by Lord Caspar Peucer [Caspar Peucer] (which I myself first beheld on 7 November, at once from the sixth hour P.M., in the tenth celestial house) — I have, my most learned Wolf, read again and again with great pleasure, attentively and carefully, as a letter written by a man more skilled in mathematics than anyone of our age; and I have compared its observations with my own.

We have observed the northern declination of this star from the equator, in the meridian circle from the horizon, in both its greatest and least elevation, and we have found it to be the same, namely 61 degrees 48 minutes, very nearly — measuring it three or four times over. And so we judge that it is set, perhaps, in the sixth division of Taurus [♉]. But as for its true latitude — by what means it ought to be taken, whether by the quadrant or by any other instrument — since up to now we have found nothing sufficiently established, and since for finding the true longitude of the star both the declination and the latitude must be known, we cannot indicate its place except approximately [platicce]. If we define its latitude absolutely as 54 degrees (just as that man from Ulm [Ulm] reports it), we gather, by the doctrine of triangles, from the vernal equinox, 5,947,007 particles, to which corresponds a circumference of 36 degrees 29 $\frac{7}{12}$ minutes. That is to say, the longitude of the star, reckoned from Aries, comes out — from the given declination and the latitude found — to 6 degrees 29 $\frac{13}{15}$ minutes of Taurus [♉].

We observed its greatest altitude above our horizon on 21 November, in the year 1572, in the evening at the hour 7 $\frac{3}{4}$ after midday, in the meridian circle, to be 76 degrees 34 minutes. Its least, in the same circle, we observed at the hour 19 $\frac{3}{4}$ nearly after midday, to be 20 degrees 9 $\frac{2}{3}$ minutes. On 4 January of the present year 1573, in the morning at the hour 4 $\frac{1}{4}$ before midday, we found its least elevation; and on the same day in the evening, at the hour 4 $\frac{1}{4}$ nearly after midday, we again found its greatest altitude in the meridian circle to be the same as on 21 November, in the year 1572.

The fact that the greatest and least elevation, taken together, yield for us the same number seems to lend credence to there being no difference between the true and apparent place of this star — the same number which all the fixed stars (those that are always in the open and never set) produce when composed from their greatest and least altitude, and the half of which perpetually shows the Elevation of the Pole, or the latitude of the region (stars which, although they differ in position, differ not at all in quantity). If indeed the Elevation of the Pole

at Wittenberg [Wittenberg] were known to us, the difference between our observations and Peucer's [Caspar Peucer] would also be established. But let us suppose it to be 51 degrees 50 minutes, just as Apian [Peter Apian] took it, and after him Cyprian [Cyprianus Leovitius] noted the same in his ephemerides; and if to this be added the star's distance from the zenith (which Peucer found to be 10 degrees 4 minutes toward the North, in the circle of altitude), there results a declination of the star in question, northern, of 61 degrees 54 minutes. And so, between our value (which, as we noted above, was found to be 61 degrees 48 minutes) and

Peucer's earlier observation, there would be a difference of 6 minutes. Now if we add the least altitude (which Peucer observed at Wittenberg [Wittenberg] as 23 degrees 33 minutes) to the complement of the elevation, we shall again gather the northern declination of the star. I call "complement" the number that fills out the quadrant — that is, 90 degrees less the remainder. So, with the latitude of Wittenberg set at 51 degrees 50 minutes, its complement is 38 degrees 10 minutes; and if the least altitude of the star (which was 23 degrees 33 minutes) be added to this, the northern declination of the star is gathered as 61 degrees 43 minutes. And thus there is a difference of about 5 minutes. This declination, from that later observation, will be less than ours, since from the earlier observation of Peucer it came out greater.

That this is a comet — which the Greeks call κομήτην [Greek: komētēn, "comet"] — I do not doubt at all; and although it may not be a star, yet because it shines like one, this and similar bodies are called by most authorities "stars," and by Pontano [Giovanni Pontano] "secondary stars." There are those who would deny that this body is a μετέωρον [Greek: meteōron, "meteor," a thing on high], and would hold that it is situated within the eighth sphere and that of the Moon; yet because we have as yet no certainty about its distance from the Earth, we judge this and similar bodies to be stars, of the kind that have drawn together such matter in the air, and — as the experience of all ages teaches — they gradually diminish and are consumed. Just so, this body of ours too has manifestly waned, and now appears far smaller than it did at the beginning. Moreover, those bodies which exist in the ethereal and incorruptible part of the world neither increase nor diminish, much less waste away, but are seen to remain perpetually uncorrupted. For this reason we judge that this star of ours (of which we write) also exists in the elementary, or corruptible, part of the world. And since (provided only that it was kindled from Jupiter, as Peucer supposes) it is established that it will reach the sixth degree of Taurus [♉], and the place of the comet, about the end of the month of March, we conjecture that it will be

extinguished once more, or about the third day of April, or at the very latest will entirely fade away into nothing on the seventeenth day of that same month.

We read that a similar star appeared in the time of the poet Claudian [Claudian], in his Panegyric on the Fourth Consulship of Honorius [Claudian, *Panegyricus de Quarto Consulatu Honorii Augusti*], a star which he himself sang in his poem to have been seen at midday and to have been like Arcturus in magnitude. The histories testify that many calamities followed upon this — in particular the Gothic invasion. Therefore I judge that this comet of ours too portends some great and fateful thing to the world. A certain Guilandinus [Melchior Wieland (Guilandinus)], an eminent philosopher in Italy (as Blotius [Hugo Blotius] writes to my brother), laughs at those who attribute every kind of sense and reason to bodies devoid of them — that is, to a body born of a thick exhalation — and who suppose it has the power to change and overthrow human affairs. "Rarely," he says, "does it happen, in so great a multitude of kings and princes every year, that some one or another does not die. What wonder, then, if in that year too in which a comet appears, the same thing happens?" And so on. Thus he. But for my part, far from finding it ridiculous, I judge it to be all too ominous; and by everyone to whom this portent presents itself to be seen, I judge that God, best and greatest, principally exhorts all men to repentance and to the invocation of His name, and warns what ought to be done or guarded against, and shows the punishment that threatens. Then again, even granting that these portents have their natural causes too, by which they are excited — namely, the stars, both fixed and wandering — yet I think this authority is to be attributed not to that body born of thick exhalation, but to the stars in the heaven, which have drawn together such matter in the air, and which have, implanted by God, the greatest power of acting upon our own bodies too and upon earthly things. And especially this comet seems to announce misfortunes and ruin and seditions to those who lie at its zenith, and to the sign in which it appears. And since it is fixed in Taurus, and up to now motionless, abiding in that very place of the heaven where it was first formed — those who profess that science say that it threatens chiefly the Northern and Western peoples: then Muscovy [Moscow / Russia], Cyprus [Cyprus], Greater Poland [Poland],

Switzerland [Switzerland], Lorraine [Lorraine], and whatever other states lie beneath this sign — and finally that it threatens destruction to the cities of the Christians. It will bring forth an enemy, too, not from elsewhere, but in that same region and in neighbouring places, a war. From these matters one may argue this also: since the comet long offered itself to be seen, the effects stirred up by it will be the more violent and, as it were, the more lasting. May the merciful God, the

Father of our Lord Jesus Christ, have mercy on His Church, and in this last old age of the world deliver it from these threatening and greatest perils, and from the fierce and savage rage of the Devil and of tyrants, from wicked parricides, robberies, lies, and finally from every evil; and may He carry it in His womb and in His bosom, and protect it, just as He has promised. With this I shall make an end of writing, and I earnestly, earnestly beg you to take this — written in language quite unpolished, and at greater length than I had intended — in good part and fairly, and to continue, as you do, to love me always. Given at Augsburg [Augsburg], from my house, 19 January, in the year 1573.

Your most loving friend,

Paul Hainzel [Paul Hainzel].

These were Hainzel's letters, which we shall now examine in order. The declination of the star, which he fixes from his own observations at 61 degrees 48 minutes, we have set in Chapter Four [Cap. IV] from those same observations at half a minute less, because we have compared all his greatest and least altitudes with one another and have limited them in the proper way — which he himself neglected. But the difference is exceedingly small and of no consequence.

That he places the star in 6 1/4 degrees of Taurus [♉] he does too loosely, perhaps from the inspection of some globe. For since he could not obtain the true latitude by the quadrant, nor had any other instrument suited to this office ready at hand, and since (as he rightly asserts) the longitude of the star could not be predetermined from the declination alone — that value, indeed, which he assumes from a certain man of Ulm [Ulm] (whose writing I have not seen, nor do I know whom he means), namely precisely 54 degrees, is too great, for it exceeds by a quarter of a degree. It is therefore no wonder that, by the doctrine of triangles, from this given latitude and his own assumed declination, he placed it at about 6 1/4 degrees — 24 minutes earlier in that place than the one it actually held in the heavens.

Next he compares the greatest and least altitudes of the star with one another, just as we did in Chapter Four [Cap. IV], though we examined and corrected all the observations among themselves a little more strictly. As for those at least which he took on 4 January and 21 November, he uses them without painstaking limitation, and indeed the difference is so exceedingly small that it scarcely deserves any mention. He gathers from this that there is no difference whatever between the true and apparent place of the star — which is the same thing — and that it must be pronounced free of all parallax. And from this he infers that the

greatest and least altitude, composed and halved, produce exactly the same elevation of the Pole as do the other circumpolar stars, coeval with the world; and since these reject all diversity of aspect, he builds most rightly upon

confirms that this New Star, no less than the others, was entirely free of all parallax. Earlier, in the fourth chapter, I reviewed a number of stars revolving around the pole rather than passing beneath the horizon — stars Hainzel had observed — whose greatest and least altitudes consistently yielded a pole-elevation in the place of observation of $48^{\circ} 22'$ [Margin: P. 48. /. 22.]. The same can also be gathered from the greatest and least altitude of this New Star. It is therefore necessarily concluded that in its revolution the star admitted no difference from the rest of the fixed stars, and was wholly free of any variation of aspect.

Hainzel also wanted to verify the same point from the observations Caspar Peucer had made at Wittenberg. But because he assumed the pole-elevation in accordance with Apian's [Apianus] erroneous determination, namely $51^{\circ} 50'$ [Margin: P. 51. /. 50.], he slipped into a certain error: in the upper position he makes the declination six minutes greater than his own — which is the truer — while in the lower position he makes it five minutes less than it should be. This happened not so much through any fault of the observation made at Wittenberg as because the pole-altitude there was not correctly assumed.

For if no account at all is taken of the pole's elevation (since that is in fact unnecessary, given that the star is established to have revolved uniformly about the pole like the others — as Hainzel's own observations themselves attest), then, had he combined the greatest altitude received at Wittenberg, which on account of its distance from the zenith was $10^{\circ} 4'$ [Margin: part. 10. min. 4.], that is, $79^{\circ} 56'$ [Margin: part. 79. /. 56.], together with the least, $23^{\circ} 33'$ [Margin: part. 23. /. 33.], he would certainly have found that the star described a circle around the pole whose diameter was $56^{\circ} 23'$ [Margin: P. 56. /. 23.]. Half of this is the star's own distance from the pole, $28^{\circ} 11\frac{1}{2}'$ [Margin: P. 28. /. $11\frac{1}{2}$.]. And this is likewise the complement of the star's declination; from which the true declination of the star comes out, by both routes, to $61^{\circ} 48\frac{1}{2}'$ [Margin: part. 61. /. $48\frac{1}{2}$.] — exceeding the consul's [i.e. Hainzel's, the city councillor's] own note by only half a minute.

It is therefore clear that those Wittenberg observations of the star's altitude which Peucer reports were off by scarcely a single minute. From them, taken together, the pole-elevation can be gathered to be there $51^{\circ} 45'$ [Margin: part. 51. min. 45.] or nearly so — about five minutes less than what Hainzel assumed from Apian. This was also the very reason why he was deriving such discordant

declinations in the upper and lower positions. But I shall treat this matter of the pole's altitude more fully later, in the following chapter.

Peucer rightly affirms, too, in his letter, that no discrepancy was found between the true and the apparent place, and that for this reason no parallax whatever was detected. This makes me wonder why he says that its visible place fell at 6° of Taurus [γ], when from the very absence of parallax it would necessarily follow that the visible and the true place were one and the same. Indeed, he also takes the sixth degree as its longitude in too broad a manner, since it should rather be referred to the end of the seventh degree — being, as the completion of seven degrees, short by at least six minutes. As for the rest that Peucer added in the same letter concerning the star's immobility, the purity and splendor of its light, its radiation, scintillation, and magnitude, these are

entirely correct, and closely accord with my own remarks. But in judging it to have been a comet — though he does not affirm this with certainty, since he had still hesitated somewhat about its altitude — he seems here, for the sake of Peripatetic doctrine, in which he had been trained and brought up, to be detracting from his own observations. Unless, against their pronouncements, comets are generated in the heavens, he could not concede so great an altitude above the Moon as would render the parallax imperceptible — though in itself this is not so absurd, even on the supposition of the Aristotelians. For we have in fact, by frequent and careful inquiry, explored that comets really are produced in the heavens, and that some of them exhibit scarcely perceptible parallaxes, as will be shown beyond doubt in the following volumes [Tomis sequentibus]. Yet not even so should this star be likened to those comets, since it had almost nothing in common with them — except that it arose suddenly, and, being large at the start, gradually diminished until it disappeared altogether. In all else it presented itself as the equal of the true fixed stars, as I have treated more fully elsewhere. And so I shall point out that this star is only improperly called a comet.

In the same way, although that excellent man Hainzel, scrupulously examining the altitudes of the stars by means of his great quadrant, had ascertained reliably enough that this body took on no parallax at all — and from this, beyond doubt, knew that it was by no means below the Moon, but must necessarily be removed far above the Sun — he nevertheless did not hesitate to assert that it was a hairy star or comet, and to be numbered among those which Pontanus [Pontano] and others call secondary, at least because it appeared to blaze, as though some star had been kindled. But it was not blazing, nor did it display any flame; rather, like

the other stars, it shone with radiant and scintillating light. (Though indeed comets neither burn nor blaze, as I shall argue elsewhere.) Hainzel does admit that there are some who would place this star within the eighth sphere [Octavam Sphaeram], in the ethereal world; but because he has as yet explored nothing concerning its distance from the Earth, he does not dare to subscribe to this view. And so, either tacitly or by his own observations, he detracts from it — or rather, what follows from it he has not considered carefully enough. For when he grants — as he himself admits — that this star made no distinction between its apparent and its true place in the daily revolution, because it stood everywhere equidistant from the pole in the same manner as the rest, and presented the same altitude as they, it follows without any hesitation or contradiction that it admitted no parallax at all; and therefore that it must be raised altogether above the Moon, toward the eighth sphere — indeed, that it ought to be far nearer to the latter than to the former. For it is certain that, had it been as near to us as the Moon is, it would have shown a somewhat greater parallax than a whole degree at the lower altitude, and at the highest it would have made the same parallax a quarter of a degree, just as I demonstrate of these matters in Chapter Six [Cap. Sexto]. By no means, therefore, would it have been carried uniformly around the pole; nor would it have shown the same altitude as the rest

of the stars; rather it would have made this about $47\frac{3}{4}^{\circ}$ [Margin: part. $47\frac{3}{4}$.] or so, falling short of the true value by nearly two-thirds of a single degree. How could so great a deviation, with an instrument of such magnitude — one that even subdivided the individual minutes — have escaped notice? And in places still nearer to the Earth this discrepancy would have stood out far more evidently. Hainzel could therefore, with sufficient certainty, have gathered from his own observations — had he weighed them more attentively — that this star is in no way to be brought down below the Moon into the elementary world, and that he needed no other inquiry than his own.

But as for his opinion that, on account of the change and diminution of its body, the star is to be placed in the air and in the elementary or corruptible part of the world — on the grounds that such alterations cannot be seen there or in the celestial bodies, as they are in the rest of the world coeval with the stars — this is of no great weight; not such, certainly, that anything can be detracted from the plain certainty of the observations and from the geometrical demonstrations deduced from them. On the contrary, one should far rather stand by sure observation and indubitable demonstration, and from these conclude that the heaven does receive certain new bodies, themselves liable to change and dissolution, against the long-received opinion — than contradict reliable

observations and geometrical truth on the strength of the uncertain and doubtful conjectures of the natural philosophers, propped up by the authority of Aristotle alone. Nor was this star (as Peucer supposed) kindled from Jupiter [Iove], or had any commerce with that planet, except that it recalled it by its color and the majesty of its light — or rather recalled Venus from the outset. He was wrong, then, to want to consider whether Jupiter's progress was overtaken by a stronger station, and whether it drew this star along with it to some other place. For the star was bound to Jupiter by no bond or magnetic force, just as it was bound to none of the other planets — indeed, not even to the Sun itself, which all the rest obey; rather, like the other fixed stars, it stood perpetually, as long as it lasted, in one and the same place. And so Hainzel waited in vain for its consummation when Jupiter should reach 6° of Taurus [♉], at the end of the month of March 1573, or at the latest the following April, since it persevered about a full year longer. So fertile in begetting further errors is one absurd assumption.

Nor can I sufficiently marvel that so distinguished a man — grave in character and intellect, and a most devoted student of the truth — failed to consider that these two things cannot stand together at once: that the star was destitute of all parallax, and yet was nonetheless beneath the Moon. But there happened to him what usually happens to men otherwise not unskilled: things they have received from their elders through someone's inveterate authority they observe so scrupulously that, even when those things cannot stand against evident reasoning and experience itself, they perceive this clearly enough by themselves and without any prompter, yet still count it a sin and impute it to frivolity to depart from a long-approved opinion confirmed by long use.

And so it is no longer surprising that, in matters of religion, men fight so fiercely for ancestral decrees, even when Holy Scripture sometimes plainly enough proves the contrary. There are also many things in these matters which, by quibbling minds, can be dragged in various directions, as on a tragic buskin, and are sometimes delivered obscurely, as if in riddles. For if, in those things which lie open to the external senses and can be reliably explored with the help of suitable instruments and demonstrated geometrically, an anciently received opinion so detains and as it were blinds even some who are deeply devoted to the truth, that they cannot or will not discern what the fact is — then why should it not happen, in those matters which are not so easily evident and can be variously expounded, and which have been disputed back and forth for very many ages? So that one may not unjustly exclaim with Lucretius: *O blind minds of men, O blind hearts!* and so on.

But in truth, after Hainzel saw the little treatise on the star that I had composed at that time, in which we demonstrated that the star had necessarily been above the Moon — so that, led by sure reasonings, we did not hesitate to raise it into the highest sphere of the fixed stars — he too retracted his opinion, recalling his observations into agreement with these conclusions, subscribed to my assertion regarding the star's ethereal position, and no longer doubted that the matter stood so.

That most upright man was therefore excusable in that he was not at once able, at the very outset, to penetrate to the inner sanctuary of truth after a desisting from an error so long ingrained in the schools. For one does not enter all at once, since many obstacles and the labyrinths of human opinion, hatched by idle conjecture, are for the most part a hindrance. But it is the mark of a man of noble character to acquiesce at last in the acknowledged truth, and not to defend his own lapses by biting at them — just as that distinguished Hainzel here also did.

The star which Honorius mentions in his fourth consulship, such as it is described by the poet Claudian [Claudianus] in verse, may have been seen at midday and discerned by day, with our keen eyesight prevailing at the outset; yet it does not necessarily follow on that account that it was a star of that kind, that is, this New Star or anything new. For it might have been the planet Venus, which not rarely is seen even at very noon, as I myself have done several times; and almost everyone, if they catch sight by day of anything of the sort, supposes — because it happens so rarely — that it is something new, and they are mistaken. The verses of Claudian are these:

Seen even at midday, while the peoples marvelled, a bold Star — by day,
with nothing to doubt, and with no blunted tail — Faint, yet such as
Boötes is reckoned at night.

So then, whether at that time the daytime star of Venus appeared — from which Claudian, taking the occasion, wished to congratulate Honorius on his new and fourth consulship, or even (as is the poets' custom) to flatter him — or whether some comet, appearing by day without a tail, then shone forth, or whether even some new

that it was a genuine star, I conclude that from these few words of Claudian no firm conclusion can be drawn beyond this point.

From certain preceding lines, the appearance of this star is to be referred rather to the birthday of Honorius — the year in which he was first designated consul, and not to the beginning of his fourth consulate. And so far as history makes

clear, his birth fell in the year 388 from the birth of Christ. Around that time, or rather in the following year (if the reckoning is sound), Cuspinianus [Johannes Cuspinian] writes that a certain star rose in the north around cockcrow, shone like the morning star [Lucifer], and disappeared within three weeks. Whether this was the very star of which Claudian speaks, or not, we leave in doubt.

What Guilandinus [Melchior Wieland], the Italian philosopher, brings forward contains nothing new: out of the arrogance of their own intellect, some of those men diminish the wonders displayed by God and Nature. Nor is it rightly maintained by him that comets consist of a fatty exhalation, and that on this account they signify nothing, or have no power to alter things here below. For the premise is false as regards their matter, generation, and place, as will be made plainly clear from the books that follow. And yet the things that happen on Earth after the creation of comets and of these adventitious stars [Ascititia Sidera] do not all depend on them, since beyond doubt they have other causes, and could in the same way have come about even if no comets had preceded. But of this we shall treat more fully elsewhere.

What Hainzel [Paul Hainzel] afterwards adds about this star, right up to the end of his letter, in an astrological vein — proposed piously enough and prudently — I do not wish to repeat here. To do so, as I have likewise attested before, would go beyond the limits of my plan.

But since no others in Swabia, so far as I know, have written anything about this star — for the man of Ulm [Ulmensis] whom Hainzel mentions in his writing, as I have said, I have not seen — let us pass from here into the neighboring Duchy of Württemberg, and find out what Mästlin [Michael Mästlin], then living hidden away in the small town called Backnang, thought about the same matter.

M. MICHAEL MÄSTLIN [Michael Mästlin] OF GÖPPINGEN

[*M. MICHAEL MAESTHLINVS GAEPPINGENSIS.*]

It is indeed a slight work, if you look only at the number of its leaves and lines; but if you weigh the substance of the matter it contains, it is in most respects far greater, fuller, and more solid than what most others have published on this star. Its author is M. Michael Mästlin, at that time parish priest [Parochus] in a certain town called Backnang, afterward in the University of Heidelberg, and now Professor of Mathematics at Tübingen. And although in recording the phenomena of this star he employed no instrument — being at that time perhaps without one — yet by the aid of a thread [Filum] alone in measuring

its place and its lack of parallax, he aimed so near the very mark of the truth that he far outdid many of those who used I know not what instruments. And because that writing is at once learned and vigorous, I am pleased to set the whole of it down here. For it is not, in itself, so very long.

DEMONSTRATION OF THE ASTRONOMICAL PLACE OF THE NEW STAR, BOTH WITH RESPECT TO THE CENTER OF THE WORLD AND WITH RESPECT TO THE ECLIPTIC AND THE EQUATOR

[*DEMONSTRATIO ASTRONOMICA LOCI STELLAE NOVAE, TVM RESPECTV CENTRI
MVNDI, TVM RESPECTV Signiferi & Aequinoctialis.*]

COMPOSED BY M. MICHAEL MÄSTLIN OF GÖPPINGEN

[*CONSCRIPTA A M. MICHAELE MAESTLINO GAEPPINGENSI.*]

In the past year 1572, in the first week of the month of November, a certain new star began to appear in the seat of Cassiopeia, touching the edge of the Milky Way [Galaxia]. By the brightness and unusual, astonishing magnitude of its splendor, it was seen to surpass in appearance not only Sirius [Syrius] — the greatest of the fixed stars — but even Jupiter, and almost Venus. For when the sky was clear and the sight was reasonably keen, it could be discerned at whatever hour of the day. It blazed with a coruscating splendor, gleaming with a whitish color not unlike Jupiter's and Venus's, which, however, in the month of December turned to a fiery or saffron hue, then to blood-red, then to one color after another, until at last, around the end of February, it returned to its former state, while its magnitude too was seen to diminish not a little.

Various judgments and opinions about it have been heard from men who were not unlettered. Some granted that it was a natural and perennial star, and not a new one. If they were to say this, I am astonished at what carelessness — or rather what idle curiosity — possessed Hipparchus, Ptolemy, Alphonsus [Alfonso X], and in our own age Copernicus together with the others, who passed over this most brilliant of all the stars, while they busied themselves with noting tiny little stars of the sixth order hidden away in the most obscure places — so that (not to make mention of our own observations) none could be found among them by

whom this star, conspicuous beyond even the least of them, had been seen before October of the year 1572. Others wished it to be the Lyre's harp-star [Lyrae fidicula, i.e. Vega], others the Charioteer's she-goat [Heniochi capella, i.e. Capella], others Boötes' Arcturus, others again Hesperus, others Saturn, others some star or planet I know not which. But those men seem to me to have but poorly imbibed the science of astronomy, since they do not know the said stars: not at the sixth or seventh degree of Taurus and next to Cassiopeia, but in other parts of the sky — namely Lyra at 8 degrees 30 minutes [of its sign]; Capella at 16 degrees 10 minutes; Gemini [II] — Arcturus at 18 degrees 10 minutes of Libra [♎] — as has been noted by the experts; and they do not cohere [with the new star]. Nor have they observed, either from observations or from the tables of the motions, that any of the planets strays 8, much less 54, degrees from the ecliptic, as this new star does. Others not rarely said that exorbitances and transits of stars of this kind occur, with their places changing. But by what star they suspect it to have migrated thither I do not know, for none of the rest (those at least that rise above our horizon) is missing from its accustomed place — unless perhaps some Canopus or the like, three very bright ones of which the Portuguese sailors saw near the South Pole — to have ascended to us, they are willing to affirm. But if this were consistent with the truth, we should rightly reprehend (though on their authority) both Aristotle and Ptolemy, who fastened upon us the claim that no change had been detected in past ages in the heaven, particularly the starry heaven. But this change of color of the star, and the lessening of its

magnitude, sufficiently refute all these men. Others have invented that stars of this kind return at single intervals of a hundred or four hundred years: but the things they assert are not corroborated by any phenomenon of any age.

Certain others, however, supposed that it was situated not in the aetherial but in the upper aerial region, and that it began the conflagration of a certain comet. And even today many pronounce it to be a comet. But by accurate observations we have been taught that this prodigious star is to be numbered not merely not among meteors, but not even among the planets — rather among the stars of the eighth sphere, or the firmament.

For on the sixteenth before the Kalends of December [16 November], at the 7th hour after midday, I observed its place very diligently, when it was applied to the meridian at the summit of the heaven. On the following day, at the 5th hour before sunrise, when it was nearer the horizon outside the middle of the sky, I again noted its place. On the same day, at the seventh hour before midday, I considered its apparent place once more, since indeed — having returned

through the meridian to the lowest point of its circle — it occupied that point; and so, because of the nearness of the Pole, it is not subject to the rising and setting [reckoning]. The same was carefully done by me on the following days. Yet by all these observations its place in the eighth sphere was found to be the same — not, by a single scruple [minute], either differing or changed, up to the present time, from when it began to be observed. Some indeed assert that it has advanced toward the Pole by nearly two degrees; but I have found none of these things to be so. Since, then, in the diurnal revolution no discrepancy of motion can be perceived by the senses, it will easily be demonstrated from Ptolemy's *Almagest* that its true motion does not differ from the apparent — and from this, that its distance is so great that, compared to it, half the Earth's diameter is incomparable. From which we necessarily conclude that it cannot exist in the regions of air or of fire, which are otherwise wont to be the seat of comets, of other meteors, and the like — because there it would clearly produce an evident commutation, that is, a parallax variable from hour to hour. Hence too it is certain that it is not fastened to the sphere of the Moon, for in the same way it would have a notable magnitude of half the Earth's diameter, which would make it (if it were at the vertical altitude of 20 parts in the circle) nearly equal to the lowest altitude of this Moon, when, according to Copernicus, it is distant 52 degrees 17 minutes, in Earth-radii [semidiameters of the Earth], it would yield a parallax of 63 scruples of the first order; but at its highest, when its distance is 68 with a third of the Earth's semidiameters, it changes the apparent motion from the true by 48 minutes. This may be seen from the Prutenic Tables and from Copernicus. But if the Moon produces so great a parallax, it would make this new star far greater — if it were in the elementary region, as being nearer to the center of the Earth (as Peurbach [Georg Peurbach] asserts). And because it eludes all sense of the spheres of the higher planets, compared to the magnitude of the Earth's diameter, we shall declare its evident argument [proof]: its apparent motion offers proof — on which account, until it was exactly known, we are unwilling to pronounce anything certain; if indeed only by the help of motion is it permitted to astronomers to ascend to the stars, and to measure the distances of the stars and the spheres, and their magnitudes. But this cannot be thoroughly investigated except by long observation. We notice, moreover, that it accommodates itself to the motion of no planet, not even the slowest, but is carried around by a single, simplest daily revolution, just as the fixed stars are (of its own motion, such as appears in the fixed stars, since it is by far the slowest, we do not here treat) — the same from the beginning of its appearance to the present day; which could in no way happen if it were fastened to the sphere of some planet, for as may be seen [in Book] 5 of Copernicus, it would not be exempt from

commutation and motion. From which it is manifest that this star is elevated far above all the planets, and so is set among the non-wandering [fixed] stars, in the firmament. And the same thing is also proved by its twinkling light, from which most planets are exempt.

From what has been said it is clear that the appearance of this new light does not depend upon a natural cause, such as most of those enumerated above have endeavored to assign, nor is it to be called a comet, but rather a new star — unless we are willing to say that comets can be generated not only in the elementary region but also in the starry sphere, which according to Copernicus is the outermost heaven, containing itself and all things; and accordingly, that the heaven is not free of generation and corruption — against all the natural philosophers and astronomers, and against Aristotle. But this view, besides the others, is beset by no smaller an absurdity. For how great the altitude of the star-bearing sphere is, and how far it extends, is not established; whereas the distance that lies between the Sun [☉] and the Earth cannot be ascertained (as Copernicus, the prince of astronomers after Ptolemy, testifies, who, demonstrating the fixed distances of all the spheres of the planets from the center of the world, came to a halt at the starry sphere); and therefore it is impossible to measure either the true magnitude or the altitude of this star from the center of the world. Yet it is certain that it, which in apparent magnitude surpasses all the stars of the first order [first dignity], is by countless parts greater than the Earth. If, then, a natural cause were altogether to be brought forward, whence — I ask — would so great an abundance of exhalations come, sufficient to blaze in so great a fire for as many months as it now blazes? On which account I do not see why new stars of this kind, or comets, do not more often appear in the aether, just as they do in the air — unless, perhaps, that their origin depends upon a hyperphysical cause. What, then, prevents us from saying that this whole hyperphysical thing — this new star — was created by the supreme Creator in these latest times, and that, as it began miraculously, so it will miraculously cease, the cause of both being such as to escape all human understanding?

But as to what longitude, what latitude, and what place in the eighth sphere are to be ascribed to this new star with respect to the zodiac — omitting other matters — this too we have investigated in the same manner.

We find that a great circle drawn through this star, which is reckoned the fifth in the asterism of Cassiopeia, and through that star which holds the eighth place in Cepheus, passes at the same time through this new star as well. We likewise find

that the circumference of a circle drawn from the twelfth star of Cassiopeia to the twentieth of Ursa Major also intercepts this new star.

Now the longitude of the fifth star of Cassiopeia is reckoned from the first star of Taurus [♉] to be 13 degrees 40 minutes; northern latitude 45 degrees 30 minutes. The longitude of the eighth star of Cepheus is 1 degree 0 minutes; northern latitude 62 degrees 30 minutes. The longitude of the twelfth star of Cassiopeia is 1 degree 10 minutes; northern latitude 51 degrees 40 minutes. The longitude of the twentieth star of Ursa Major is 106 degrees 0 minutes; northern latitude 29 degrees 30 minutes.

Let the place of the fifth star of Cassiopeia now be assumed at point A, the eighth of Cepheus at B, the twelfth of Cassiopeia at C, the twentieth of Ursa Major at D, and let the circumferences of the greater circles AB and CD be described. But because the new star is seen in each, while it has no point other than the point of section, which is E, in common, the point E must necessarily indicate the place of the new star. Let the portion of the ecliptic FG, sufficient for the present purpose, also be marked out; and let its north pole be H, from which let perpendiculars [circumferences] be dropped to the four fixed stars, namely HA, HB, HC, HD, of which two — HB and HC — descend into I and K. Let DC and BA likewise be continued until they meet the zodiac in F and G. Finally, from E let EL be drawn, perpendicular to FG itself.

Therefore (by the eleventh porism of proposition 3 of Regiomontanus's *On Triangles* [*De Triangulis* I, prop. 3, porism 11]) HBI and HCK are quadrants, which (by the definition of the longitudes and latitudes of the stars) report the latitudes B and C by the circumferences IB and KC, while the longitudes terminate in the zodiacal points I and K, in whose poles also are E and L — if continued — by [proposition] 13 of Book 1 of Theodosius's *Spherics* [*Sphaerica* I.13], it falls. Therefore, by the same definition, L terminates the longitude, and EL the latitude of the new star. These it is our purpose to investigate by the doctrine of spherical triangles.

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Diagram. A spherical-triangle construction occupying the left side of the page, showing arcs of great circles drawn among lettered points used in the worked computation of the New Star's place. Several curved arcs converge through a central intersection at E, with a base arc running along the foot from F through I, K, L to G. The labels read, by position:

- D (top, marked with a star-burst): a point at the upper apex of the figure.
- H (upper left, below D): a point on the left arc.
- B (left, below H, star-burst): a point on the left arc.
- E (center, star-burst): the central intersection of the converging arcs.
- C (center-left, below E, star-burst): a point below the intersection.
- A (center-right, below E, star-burst): a point to the right.
- F (lower left): the left end of the base arc.
- G (lower right): the right end of the base arc.
- I, K, L (along the base, left to right between F and G): points on the base arc.

The four star-burst marks (at B, C, A, E and D) denote the positions of the fixed stars used as reference, with the New Star at E.

The worked computation follows. From the known arc B I, the latitude of star B being $62^{\circ} 30'$, the remaining arc B H up to the quadrant is found to be $27^{\circ} 30'$. Likewise, the latitude of star A, which is $45^{\circ} 30'$, subtracted from the quadrant leaves H A = $44^{\circ} 30'$. In triangle B H A, then, two sides B H and A H are given, together with the angle B H A — which the difference of longitude defines, as is evident from Copernicus, at $12^{\circ} 40'$. By *De Triangulis* IV [Regiomontanus, *De Triangulis* IV], the angle H B A will be obtained as $151^{\circ} 0'$. Once this is removed from two right angles, the angle I B G is known as $29^{\circ} 0'$; and the angle of triangle B I G, whose side B I is likewise given as $62^{\circ} 30'$, together with the angle at I — which by [Regiomontanus] *De Triangulis* III.17, or [Theodosius, *Sphaerica*] I.15, is a right angle. Therefore, by the fourth proposition of Copernicus's spherical doctrine, we measure the angle at G as $77^{\circ} 4'$; and I G, the arc opposite the longitude I, which is $1^{\circ} 0'$, fixes the longitude G, from the first star Υ [Aries], at $27^{\circ} 11'$. This we shall set aside.

In the same way, in triangle C H D: by C K, the latitude of star C, which is $51^{\circ} 40'$, C H is found, which remains as $38^{\circ} 20'$; and by the latitude of D, which is $29^{\circ} 30'$, D H is determined as $60^{\circ} 30'$. The angle D H C yields the difference of longitude, $104^{\circ} 50'$. From this, by Copernicus XI, the angle H C D is elicited as $60^{\circ} 17'$.

Likewise of triangle C F K: given the side C K, $51^{\circ} 40'$, and the angle F C K (equal to its vertical angle H C D) of $60^{\circ} 17'$, together with the right angle at K, there is produced — by [Regiomontanus] *De Triangulis* IV.27 — the angle at F, $57^{\circ} 24'$; and F K, $53^{\circ} 57'$. Subtracted from the longitude K, $1^{\circ} 10'$, this leaves the longitude F, $307^{\circ} 13'$. This too we shall note.

For triangle F E G, then, by the preceding demonstrations we find the angle at G, $77^{\circ} 4'$; and the angle at F, $57^{\circ} 24'$. Now the side F G, after the longitude F has been

subtracted from G, is given as $79^{\circ} 58'$. We shall therefore be able, by [Regiomontanus] *De Triangulis* IV.31, or Copernicus XII, to find the side E F, $73^{\circ} 44'$.

Finally, of triangle E F L, the side E F has come out as $73^{\circ} 44'$, with the angle at L a right angle by construction. Therefore, by Copernicus IV, we shall have E L = $54^{\circ} 0'$ (very nearly), and F L = $61^{\circ} 33'$. Now the longitude F had been assigned in the preceding computation as $307^{\circ} 13'$. If to this we add F L, we shall pronounce the longitude L, from the first star γ [Aries], to be $8^{\circ} 45'$.

The longitude of the New Star according to L is therefore $8^{\circ} 45'$; and with the precession of the equinoxes adjoined, its place is $6^{\circ} 35' \gamma$ [Taurus]. The latitude according to E L is $54^{\circ} 0'$ north.

Now that the longitude and latitude of the New Star have been found, we shall easily learn from Copernicus its declination from the equator, $61^{\circ} 50'$ north, and its right ascension —

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— right ascension, $359^{\circ} 56'$. And the degree with which it culminates [mediates the heaven] is $29^{\circ} 56'$. [recte: this should read the degree of the ecliptic that culminates with it; reading uncertain] $\times$

What this New Star may portend, we shall leave for others to debate. For our part, it has been our pleasure to record only what an astronomer who loves the truth would declare about it. Completed on the 4th of the Nones of March [recte: 4 Nones = 4 March], in the year 1573.

These were the things that the most learned Mästlin brought forward concerning this star, which I shall now take up to consider and weigh in order.

He rightly places the time of the first appearance, in agreement with us, at the beginning of November — its first week, that is. For if it had been seen in October, as certain men have reported on common hearsay, surely Mästlin, beyond other German astronomers, would have noticed it, since he kept watch over the contemplation of the heavenly bodies more diligently than most.

So too, regarding the star's position, its magnitude, its brightness — and the fact that it was visible by day from the start — its color, and the changes in these, he sets out a general account consonant with our own treatment.

As for the various opinions of others — some of whom held that this star was natural and had always been situated there; others, that it was one of the larger stars toward the north; others, a planet; others, the wandering aside of some star; and certain men, that it was a comet (as human opinion fluctuates in various ways) — for the sake of clarity he reports that they are sound, although figments of this kind, put forward by various authors, betray so unskilled a grasp of the matter that they scarcely seem worthy of a reply or a refutation.

Most truly, however, Mästlin goes on to maintain that this prodigious star is to be counted not among the meteors, nor even among the planets, but among the stars of the eighth sphere [sphaera octava]. He proves this from the fact that, both in its lofty position near the vertex and lower toward the horizon, it kept exactly the same place. For this reason it could be neither in the elementary region nor in the sphere of the Moon, since a quite evident discrepancy between its true and apparent place would have occurred there. And that it found no place within the spheres of the planets either, but that it must necessarily be raised into the orb of the fixed stars, he judges — and rightly so, for that is how the matter stands — and he draws a fitting argument from its immobility. But that it was not within the spheres of the planets for the reason that, had the fixed star been carried along together with them, it would imply no necessity, unless the planetary orbs were real and solid — as Mästlin imagines, perhaps in vain. So too the constancy of its motion does not sufficiently prove that it was removed beyond the bounds of the planets, unless we wish to hold, with Copernicus, that the Earth is carried around annually — which still needs a far greater proof; indeed, we shall show clearly in its place that the matter by no means stands so. Therefore the truth was not to be confirmed from arguments that are not merely doubtful in themselves but plainly false and absurd, when it could otherwise be done far more correctly and fittingly. It is nonetheless certain that this star was not within the orbits of the planets,

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— but stood among the most remote stars of the eighth sphere; and he also rightly adduces its scintillation as a testimony to this.

That it admitted no parallax — although he, lacking suitable instruments, does not prove it from his own particular observations — he nonetheless detected by means of a thread: that it was as near the vertex as the horizon, in the straight alignment, made crosswise, of the same four stars. He was able to gather quite evidently that no diversity of aspect was admitted, except so very small a one as

to be scarcely perceptible — so that on this account it could in no way be enclosed within the lunar orb. The rest he aptly inferred from its fixed situation and its scintillation: just as he also inferred this, that it should be called not a comet but rather a New Star — and that the term, commonly worn smooth in accordance with Aristotle's view, is drawn from the generation of comets, since the heaven admits no generation or corruption, and since the Earth does not supply so great a quantity of vapors as would constitute a body so vast, many times larger than the Earth itself. This indeed Mästlin urges not without reason. For that star in no way consisted of any elementary matter, nor was it to be equated with the common comets — although these too are situated in the heavens and need no terrestrial or elementary framework, which Mästlin at that time did not know. But afterward, in the two comets of the years 1577 and 1580, he himself experienced that this is so, and testified to it in public writings as well — of which, in their own time, in the books that follow.

But that he removes the orb of the fixed stars, in imitation of Copernicus, so very far beyond the sphere of Saturn, across those intervals, that this space — which lies between the Sun and us — becomes imperceptible by comparison: this will not so easily persuade me as it will convince him that the Sun truly rests at the center of the universe, and that the Earth is carried annually around it. And even if this disposition of Copernicus's world-revolutions disclosed no other absurdity, this one alone would suffice: that it admits so immense a space between Saturn and the firmament of stars, utterly empty of heavenly bodies and assigned to no use; and that the fixed stars would then have to possess an excessive and incredible magnitude before they could strike us with such light — as we showed more particularly in the Seventh Chapter [Chapter VII].

Yet that this star was many times larger than the Earth — as long as it stood altogether within the eighth sphere, not, to be sure, so far that we must hold, as the Copernican speculation does, that it was removed — admits of no doubt. For even if it were placed not far above Saturn, together with the fixed stars, it nonetheless surpassed the bulk of the Earth more than three hundred times, as we showed, demonstrated in the aforesaid Chapter. And since no elementary matter is sufficient for so great a body, and since it was a very rare sight for a new phenomenon to appear in the ether, Mästlin concludes — not undeservedly — that this star was hyperphysical, fashioned, that is, by the Maker himself, and shown to this last age of the world: a thing of nature which he nonetheless admits, not without reason, exceeds the human grasp.

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He then demonstrates the place of the New Star with respect to the ecliptic — as to longitude and latitude — by lines drawn crosswise from the four other stars, intercepting this place in their mutual contact: that it fell at $6^{\circ} 35' 8''$ [Taurus], together with a latitude of $54^{\circ} 0'$. In this the longitude falls short by nearly a third part of a single degree, while as to latitude it commits an excess of a fourth part. In the declination derived from this, however, it is too great by at least three minutes; and in right ascension and the heaven's culmination it anticipates by about half a degree. But this deviation from the very mark is due not so much to a fault of this observation by the thread — namely that these stars are not precise enough, since the New Star coincided exactly along one straight line (although here too, in this minute portion, a deviation that could scarcely be noticed by the thread might have introduced some discrepancy) — as to the fact that the places of the fixed stars, not consonant with the heaven itself, but borrowed at least from the Copernican computation, were employed in the demonstration.

For if we apply the verified places of those same stars, as our careful observation has taught us, the position of the New Star will not be so far off, but will agree much more closely with the one we found by manifold experimentation in the Fifth Chapter. And so that the Mästlinian demonstration may be seen more plainly to be founded on truer positions of the fixed stars, we shall recall it to the anvil, and resolve it anew into numbers.

**Loca quatuor Affixarum Stellarum, quibus hic usus est
Mästlinus, ex nostris Observationibus rectificata, addita
Coperniana numeratione, ut discrimen pateat.**

The places of the four fixed stars that Mästlin used here, corrected from our observations, with the Copernican reckoning added, so that the difference may be evident.

Iuxta nostram Observat. (By our observation) —				Iuxta Copernic. (By Copernicus) —			
Longitudo P.	M.	Latitu do P.	M	Longitudo P.	M	Latitu do P.	M

NOMINA
STELLARUM

	Iuxta nostram			Iuxta Copernic.		
	Observat. (By our observation) — Longitudo P.	M.	Latitu do P.	M Copernicus) — Longitudo P.	M	Latitu do P.
(Names of the stars)						
Cassiopeæ genu (the knee of Cassiopeia)	11	57 ϣ	46	2 11 2		29 45 ϣ
Cephei sinistr. brachi. (the left arm of Cepheus)	27	30 ½ Υ	62	3 28 5 ½		49 62 Υ
Cassiopeæ lucida cathed. (the bright star of Cassiopeia's chair)	29	11 ½ Υ	51	1 28 4 ½		59 51 Υ
Ursæ maior. in lucido pede (the bright foot of Ursa Major)	13	34 Ϡ	29	5 13 1 ½		49 29 Ϡ

Let the same delineation set down by Mästlin be repeated here, and let all the designations be understood just as they were arranged by him.

First, in triangle B H A — which has its side B H known, from the complement of the latitude of the left arm of Cepheus, $27^{\circ} 24\frac{1}{2}'$; H A, from the complement of the latitude of the knee of Cassiopeia, $43^{\circ} 38'$; and the angle inter-

the [angle] BHA was found to be $14^{\circ} 26\frac{1}{2}'$, from the difference of the two longitudes of the said fixed star. The third side, BA, can therefore not remain unknown: it is $18^{\circ} 10' 34''$.

Diagram. A spherical-triangle construction for the recomputation of the new star's place. A nearly vertical great-circle arc runs from D at the top down through H, E, and on toward the lower right at A; a second curve sweeps from D leftward down to B, then through C to F at the lower left. At the foot a baseline

runs across the points F, I, K, L. The star-symbols mark the principal points D, H, B, E, C, A.

- D (top): apex point of the construction
- H (upper middle, on the right-hand arc): intermediate point
- B (left of H): point B (the new star's reference position in this triangle)
- E (center): intersection point
- C (lower center-left): point C
- A (lower center-right): point A
- F (lower left): point F
- I, K, L (along the bottom baseline): foot-points of the perpendiculars

Now, from the three sides thus given, the angle HBA is $146^{\circ} 27' 23''$. When this is subtracted from a semicircle, the angle IBG in triangle BGI becomes known: $33^{\circ} 32' 37''$. The side BI, moreover, since it is itself the latitude of the star in the left arm of Cepheus, is $62^{\circ} 35\frac{1}{2}'$. And since the angle at I is a right angle, the angle BGI will be found to be $75^{\circ} 15' 52''$, and the side GI to be $30^{\circ} 28' 46''$. When this is added to the longitude of this star of Cepheus at I, which was $27^{\circ} 30\frac{1}{2}'$ in Taurus, it reveals the longitude of point G to be $27^{\circ} 59' 16''$ in Taurus — which was what this first operation set out to find.

Next, in triangle CHD, which has the side HC given from the complement of the latitude of the bright star of Cassiopeia [*Lucida Cathedrae*], $38^{\circ} 45\frac{1}{2}'$, and HD given from the complement of the latitude of the left foot of the Great Bear [*Ursa Maior*], $60^{\circ} 8\frac{1}{2}'$, and the angle CHD contained by these two sides — equal, by the difference of the longitudes of the fixed stars, to $164^{\circ} 22\frac{1}{2}'$: the remaining side DC is therefore obtained as $75^{\circ} 19' 10''$, and the angle HCD as $60^{\circ} 16' 52''$.

Afterward, in triangle CFK — from the known side KC, derived from the latitude of the bright star of Cassiopeia, $51^{\circ} 14\frac{1}{2}'$, and from the angle FCK equal to the HCD just found (namely $60^{\circ} 16' 52''$), the angle at K being a right angle — the angle CFK is produced, $57^{\circ} 3' 53''$, and the side FK, $53^{\circ} 47' 42''$. When this is taken away from the longitude of point K corresponding to the assumed star in the throne of Cassiopeia at $29^{\circ} 11\frac{1}{2}'$ in Taurus, it leaves the longitude of point F at $5^{\circ} 23' 48''$ in Pisces.

If now this newly found longitude is subtracted from the one obtained earlier at G, the arc FG comes out as $82^{\circ} 35' 28''$. And so, in triangle FEG (now drawing closer to the new star itself), since from the foregoing the angle GFE has been found, $57^{\circ} 3' 53''$, and the other angle EGF, $75^{\circ} 15' 52''$, while the side FG adjacent

to these has likewise become known, $82^{\circ} 35' 28''$ — for that reason the side EF cannot fail to be $73^{\circ} 39' 14''$.

Finally, in the right triangle FEL, right-angled at L, since the angle at F is known and the side EF is also known, as has just appeared, the side LE is found to be $53^{\circ} 38' 42''$, which gives the latitude of the new star; and besides this FL is found to be $61^{\circ} 39' 20''$, showing the difference of longitude of the new star from point F.

And since the longitude of point F was found above to be $5^{\circ} 23' 48''$ in Pisces...

when this side FL is added to it, the sought longitude of the new star comes out as $7^{\circ} 3' 8''$ in Taurus. The latitude, just now found, is $53^{\circ} 39'$, very nearly. These are the two quantities we set out to investigate by means of the verified positions of the fixed stars.

From these, if we determine the declination and right ascension by the same method we have used several times above, the result will fall into the configuration we have often employed elsewhere in this very matter:

		P.	M.	
Side	BC	2	$31\frac{1}{2}$	Distance of the poles [Distantia Polorum]
		3		
Side	BA	3	21	Complement of the latitude
		6		[Complementum Latitudinis]
Angle	CB	5	57	Difference of longitude from the
	A	2		beginning of Cancer [Differentia
				Longitudinis à principio ☿]
Hence; Side	CA	2	14	Complement of the declination
		8		[Complementum Declinationis]

From this the declination will be made clear as $61^{\circ} 46'$ north [Borea], and the angle BCA as $90^{\circ} 43' 18''$, which discloses the right ascension of the star reckoned from the winter tropic [a Tropico hyberno]. And so, with a quadrant rejected, the star's right ascension itself from the point of the vernal equinox, which is what we were seeking, remains as $0^{\circ} 43'$.

From all this it is clear that the longitude of the new luminary exceeds our own determination by $9'$, since formerly it fell short by a third of a degree; but in latitude only six minutes [scrupula] are wanting, whereas before it was over by a quarter of a degree. Thus the place of this star, by the aid of the filament alone [adminiculo solius fili], is such that — provided more correct positions of the

fixed stars are assumed — Mästlin found it more rightly than certain others who used instruments of I-know-not-what quality. Indeed it must seem all the more remarkable that by this simple and easy method of observation he hit the target so closely, than that any quarrel should be made over a discrepancy of a few minutes.

So the right ascension now exceeds [ours] by 17', whereas before — derived by Mästlin from incorrect positions of the fixed stars — it was a full half-degree too small. The declination now falls short of our determination by scarcely a single minute.

Now I shall set before the eyes, so that it may be plain at a single glance, the place of the new star as investigated by this reasoning, both with respect to the ecliptic and with respect to the equator:

	P · M.		P.	M ·
Longitud e	7 3	Taurus [♉]	Right ascension	0 43 north [B.]
Latitude	5 39 north [B.] 3		Declination	6 46 north [B.] 1

From this it appears that the place of the star does not fall before the equinoctial colure [Colurum Aequinoctiorum], nor even very close to it, but rather lies further on in the order of the signs [in consequentia] by roughly three quarters of one degree — which nevertheless exceeds our own finding by more than a quarter of a degree. As regards Mästlin's astronomical treatment of this star, then, let it suffice to have brought forward these remarks. And since he himself disclaims the astrological treatment (which I judge to have been prudently done), he releases me — who in any case gladly forgo such things — with the usual excuse.

D. Cornelius Gemma Lovaniensis [Cornelius Gemma of Louvain].

Concerning this star the most distinguished and learned philosopher Cornelius Gemma — son of that Gemma Frisius [Gemmae illius Frisij], the eminent mathematician, and in the higher disciplines too no degenerate successor of his — published his views once and again. First, while the star was still shining, he issued a few small pages about it; afterward, in his learned work *On the Divine*

Characterisms of the World [*De Divinis Mundi Characterismis*], he treated it more fully and more richly; and he even added a little more in his treatise *On the Comet of the Year 1577* [*De Cometa Anni 1577*]. What he brings forward, then — chiefly in the two earlier places (which, however, present a treatment of the star that is astrological rather than mathematical) — we shall set out, and weigh briefly and adequately in our examination.

First, then, let us look into what he wrote in the earlier papers, intending afterward to take up what is contained in the *Book of Characterisms*.

He did not hesitate to call this new star, on account of its apparent likeness to Venus, a second Phosphorus, and he asserts that it began on the 9th of November, since on the preceding day that region of the sky where it stood did not appear to those gazing at it. But by Master Paulus Hainzel [Paulus Hainzelius] it was seen on the 7th day, as he himself testifies in the letter to Wolf [Wolphium] shown earlier — and that man was surely truthful, and not at all frivolous in what he asserted. Gemma himself, moreover, contradicts himself in other writings concerning the first appearance of this star, referring it to the end of October. Thus he seems in both places to have followed the uncertain report of the crowd rather than to have had any reliable experience of its first beginning. The things he brings in about the position of the other heavenly bodies at the time this star rose are heterogeneous, and contribute nothing here.

He establishes its place at $6\frac{1}{2}^{\circ}$ Taurus in longitude, where he falls short by 24'; but in latitude he still misses by much more, making it only $52^{\circ} 40'$, when in fact it stood more than a full degree higher.

As for the Galaxy [Galaxiam] — near whose border, where the equinoctial colure crosses, this star chose its seat — he says, in Aristotelian imitation, that it is a perpetual source [fomes] of exhalations, contrary to its celestial nature. Not without reason, then, does he hesitatingly subjoin: *but the matter is still before the judge* [sed adhuc sub Iudice lis est].

He asserts that he could not detect a parallax greater than four minutes, though he is doubtful even about this, whether it may have happened through some defect of the eyes. In his *Book of Macrocosmic Characterisms* [*Liber Characterismorum Macrocosmicorum*] he excludes it altogether; and so, among those who, holding this star to be free of parallax, raise it beyond the planets along with us, we not without reason report his opinions here. He brings forward, however, no reasoning why he thinks this about the parallax, as befitted

a mathematician, nor does he sufficiently indicate from which observations he assigned it such a place.

He reports indeed that this star lay in a straight line with the more notable star in the loins of Cassiopeia and with the Bright Star of Perseus [Clara Persei] (by which the Head of Algol, or the star of Medusa [Caput Algol, sive Medusae Stella], is to be understood...

for otherwise it does not agree) and with the Pleiades; and on the other side with the Pole Star [Stella Polari] and the one that is in the haunches of the Great Bear [in natibus Ursae Maioris]. And yet, if these had held exactly, the place of the new star — reckoned according to the corrected positions of these fixed stars — would not have presented itself as he wishes, as one may test, if one applies the verified positions of the stars themselves, which according to our observations were as follows:

Positions of the stars which Cornelius Gemma used in [his work] on the new star of the year 1572, reduced to the same epoch [completum].

NAMES OF THE STARS	Longitude P.	M .		Latitude P.	M .
Bend of Cassiopeia [Flexura Cassiopeae]	8	3 ½	Taurus [♉]	48	4 north 6 [B.]
Head of Medusa [Caput Medusae]	20	13	Taurus [♉]	22	2 north 2 [B.]
Pole Star [Stella Polaris]	22	38 ½	Gemini [♊]	66	2 north [B.]
The one in the haunches of the Bear [Quae in natibus Ursae]	25	1 ½	Leo [♌]	51	3 north 7 [B.]

He makes its declination 60° 40', although it should have obtained more than a full degree plus 7'. And presently he adds its distances from certain fixed stars, which we shall compare in the table below with our own, so that the error committed may be the more readily discerned.

NAMES OF THE STARS	Distances of the new star — Gemma's P.	MOurs . P.	MThe difference of the . two P.	M .
from the Pole Star	23	4 25	1 1	2

NAMES OF THE STARS	Distances of the new star — Gemma's P.	MOurs . P.	MThe difference of the . two P.	M .
[Stella Polari]		8	4	6
from the Bend of	4	2 5	2 0	3
Cassiopeia [Flexura Cassiopeae]		8		4
from the Throne	4	4 5	1 0	3
[Cathedra]		0	9	9
from the Breast	6	5 7	5 0	5
[Pectore]		8	0	2

From this it appears how far from erroneous Cornelius Gemma's observations were [i.e., how erroneous they in fact were]: he deviated from the Pole Star by nearly $1\frac{1}{2}^\circ$, in the remaining two by more than half a degree, and in the last by nearly a full degree — which is surely too much. I cannot sufficiently wonder that he did not use the Astronomical Radius [Radius Astronomicus], the instrument handed down to him personally by his father, more correctly. For although the Radius does not yield the intervals between stars altogether exactly, it does not err so greatly in these matters; and others — among them Thaddaeus [Thaddaeus], who also without doubt measured his distances with the Radius — came far closer to the true interval. As for determining the place of the new star from these Gemman distances — which not even he himself attempted — I consider it superfluous, since they are in themselves so far off and so discordant.

As for its size and the brilliant light by which it outshone the planets, his account is not inappropriate. He is surprised that it was noticed earlier by the common and uneducated people than by the philosophers, and he advances a cause that is not entirely beside the point — though I, for my part, gave a different one in Chapter Three, one that is (sadly) all too true.

He then compares this star to the natures of the planets, saying that it had much in common with Jupiter, the Sun, and so on; but since these matters are astrological, I do not wish to take them up. In Chapter Three I sufficiently indicated which planets' form and light it imitated. If anyone wishes to infer from this that it shared in the nature of those same planets, he is welcome to do so as far as I am concerned. He next disputes whether this phenomenon ought properly to be called a star. Although much stands against this from the nature of the heavens — which he presupposes to be sufficiently well understood — nevertheless, because it twinkled, it seems he must concede that it had stable

matter and was higher than the planets. He also argues, rightly, that it did not stand still, but asserts nothing certain about what it actually was. As for his claim that this makes it like the star which shone for the Magi at the Nativity of Christ, and which moved across the whole sky — from what I discussed about that matter in the chapter cited above, it is plainly clear that the two were not alike. As for his placing the star precisely on the colure of the equinoxes [in Colurum aequinoctiorum], in a most distinguished place — namely, at the Vernal Equinox, beneath which (with Virgil and certain others) he supposes the cradle of the world to have begun — even if what he brings forward is not altogether inelegant, still, measured by an exact standard, it had passed somewhat beyond the colure of the equinoxes and beyond the beginning of ♈ itself, with respect to the poles of the world — by about half a degree, that is. But he did not investigate these particulars very carefully, being content with a broader inquiry.

What he records concerning eclipses and earlier comets, and the great conjunctions, as well as oppositions and similar configurations of the planets — as though these contributed to the present matter — is altogether irrelevant to the business. For this star was not generated by the force and energy of the others, nor did it serve as a herald [prodromus] of any portents in the heavens. If that could happen, the production of such adventitious phenomena would not be so rare — so that, on that account, Gemma himself would admit that these things are brought forward more superstitiously than usefully.

Furthermore, he intersperses certain matters of ethics and physics that bear somewhat on astrology, which I pass over. Finally he appends a kind of epilogue listing those features which he judges most to be admired in this star — features which he reckons up as seven.

I. *That it was suddenly born, of nearly equal magnitude from the beginning* — which he rightly asserts, although he later changed his opinion. And his notion that it had existed long before and gradually descended into view was mistaken: for in reality it arose suddenly and at once, and from the beginning attained its greatest size, which it did not increase but thereafter gradually diminished.

II. *That it was thoroughly bright, and twinkled in the manner of the stars* — this too lies not outside the matter, as has often been pointed out elsewhere.

III. *That its place, with respect to the primum mobile, was exactly at the beginning of ♈, at the junction of the Galaxy and of the*

colure of the equinoxes, and that its distance from the equator was 60 degrees. If these things are taken in a broader sense, they are in no way absurd; yet, taken

exactly (as he himself says), this star did not look back to the beginning of ♎, but was somewhat further on — by about half a degree, as we said before. So too it was not removed from the equator by exactly the Sextant of a circle, but was rather nearer by almost two degrees (with scarcely a quarter of one part wanting).

III. *That it kept its place unchanged throughout the whole time of its duration* — he rightly testifies. For there is no doubt that, from then up to the very end of its extinction, it clung perpetually to one and the same place.

V. *That it could be called neither a star, nor an exhalation, much less a comet.* As to the two latter points, I would not grudgingly concede them, for it was none of these — unless one wished to abuse the proper meaning and the term of comets. But why it should not be called a star, if we have added that it was new, I do not at all see. For in all other respects it was entirely like the genuine stars. That it was not one of those very stars, and as old as the world, by no means proves that it could not receive the name of star — since it was recent and exhibited some peculiar, miraculous quality, and afterward was gradually extinguished.

VI. *That, together with the stars which look upon bound Andromeda, it there expressed the sign of the Cross* — this Cornelius brought forward more superstitiously, and led on by a certain preconceived opinion, than because it bears upon the matter.

VII. *That its place in ♎, in the dodecatemory, fought by quadrate aspect with that place of the zodiac where the comet of the year 1556 ended — namely, at the 5th degree of ♎* — this too is of no moment whatever, nor does it pertain in any way to this star or its position. For the comets of earlier years do not act upon any phenomenon that comes into being later, so that this one does not act upon them either; nor do they have any correspondence with one another. Indeed, what he says — that that comet disappeared around the 5th of ♎ — does not agree with what he reports about the same comet in his book of *Cosmocritics* [*Cosmocriticae*]. For there he affirms that it ranged through all the angles of the signs ♎, ♊, ♋, until it reached the other quadrant and the sign ♎, not far from Cassiopeia, and he leaves it uncertain whether it ended there. But afterward, treating the matter more thoroughly in the same book, he corrected himself on these and certain other points.

So much, then, may suffice concerning the little pages first published by Cornelius about this star. We shall now see what he says further in the aforementioned

book *On the Characterisms of the World, or the Cosmocritical Art* [*De Mundi Characterismis, sive Cosmocritica Arte*].

And so, in Book II of that work, throughout the whole of Chapter Three, he treats expressly of this star anew. He piles up the strangeness of this marvel — that the heavens should have admitted a new star, a thing nearly unheard of and never before observed by any of the philosophers — comparing it with the things that the Sacred Scriptures testify were once done in the Sun beyond the order of nature, of which we too have made mention elsewhere.

Then, approaching his considerations more closely, he first disputes about the beginning of the apparition, and does so differently than before — to the point that he says it was noticed before the end of October by the common

people [*vulgaribus Hominibus*], rather than by the learned; yet I fear that he himself supposed this too vulgarly. As to why it was first observed by simpler minds — by those free from all arrogance and the empty swelling of pretended knowledge (as he too says here, in the place about the marvel) — rather than by the learned and those versed in the consideration of natural things: in Chapter Three I sufficiently excused this marvel, whatever it was. He says that he himself did not observe it before the 26th of November, and he truly testifies that in whatever place he then saw it, it remained perpetually unmoved. Here too he reports that it lay on the same straight line with four others of which he had spoken before — but only to the eye, and not by exact geometrical measurement. As for what the place of the star was, if the fixed stars assumed are first corrected, and how enormous his error was, I have indicated above.

But now, to mark out the matter more in alignment: this new star fell most exactly upon one and the same straight line with the tail of Cygnus, with the upper star in the Head of Cepheus within the Circle of the Galaxy; and again, toward the south, with the brighter star of Andromeda's left leg, and with the star of the Triangle at the northern angle. And he asserted that there were no stars of any evident magnitude which would be found to cross this one more exactly at a single intersection. The places of these stars, as corrected by us, are as follows.

NAMES OF THE STARS	Longitude (P.)	Longitude (M.)	Si		Latitude (P.)	Latitude (M.)	
			g	n			
Tail of Cygnus [Cauda Cygni]	29	29	≈	59	57		}
Upper [star] of the	8	4¼	Υ	61	3¼		}

NAMES OF THE STARS	Longitude (P.)	Longitude (M.)	Si g n	Latitude (P.)	Latitude (M.)	
Head of Cepheus [Superior Capitis Cephei]						B.
Bright star in the right leg of Andromeda [Lucid: duar: in dext: crur: Andr.]	6	28 $\frac{1}{8}$	♄	35	21 $\frac{1}{3}$	⌋
Northern [star] of the Triangle at the right angle [Bor: Trianguli in Ang: Orthog:]	6	24 $\frac{3}{4}$	♄	20	33 $\frac{1}{8}$	⌋

If now, from these truer places of the assumed fixed stars, one inquires after the common point of the arcs that intersect one another crosswise — the point at which the New Star must have stood — its longitude falls at 5 $\frac{1}{6}^{\circ}$ of ♄, with a latitude of 53° North; falling short by at least one tenth of what would be wanted from his own annotation in longitude, where it is deficient by 1 $\frac{1}{2}$ degrees. In latitude it has an excess of $\frac{1}{4}$; and in itself it deviates still further from the truer place of the star — by 1 $\frac{2}{3}$ parts in longitude, that is, and in latitude by eleven-twelfths of one degree.

Next he records the distances he himself observed, which, although here he promises them to be more closely aligned and better corrected than before, nevertheless even now he handles too immoderately, and deflects more than enough from the just standard. To make this more readily apparent, I shall set down the distances he there noted, together with those which our own Observation or Calculation supplies (where they had not been observed) — so that, the comparison once made, the discrepancy (which is for the most part quite evident) may appear the more quickly.

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The distances of the New Star from certain fixed stars, according to Cornelius Gemma's annotation, and our own observation upon the same.

Distances [Distantiae]

NAMES OF THE STARS	Gemma's (G., degrees)	Gemma's (M., minutes)	Ours (G., degrees)	Ours (M., minutes)	Differe nce (G.)	Differe nce (M.)
The New Star from the Pole Star [Nova à Polari]	24	40	25	14	0	26
Between the New Star and the bright star of Auriga [Inter Novam & claram Hirci]	42	4	42	28	0	24
From the bright star of Perseus [A clara Persei]	27	7	27	22	0	15
From the head of Cassiopeia [A capite Cassiopeae]	9	36	10	22	0	46
From the bright star in the back or breast [A clara in dorso vel pectore]	7	24	7	50	0	26
From the third [star]	6	36	6	53	0	17

NAMES OF THE STARS	Gemma's (G., degrees)	Gemma's (M., minutes)	Ours (G., degrees)	Ours (M., minutes)	Differe nce (G.)	Differe nce (M.)
of Cassiopeia [A tertia Cassiopeae]						
From the bright star in the loins, no. 4 [A clara in Lumbis num. 4]	4	36	5	2	0	26
From the Eleventh [Ab Undecima]	1	24	1	31	0	7
From the bright star in the seat of Cassiopeia [A clara in sede Cassiopeae]	5	4	5	19	0	15
The Eleventh of Cassiopeia was distant from the Pole Star [Undec. Cas. distabat à Polaris]	25	30	26	26	0	56

It should be noted that the star which he here calls "the bright star of Perseus" is not the same one he used earlier, when he wished to indicate the place of the New Star by means of the cross-arcs of the stars. There he took the Head of Medusa for the bright star of Perseus, which differs from this more recent star by

5° 32' / 58'. And so, since the one used here is not the same, [the comparison is affected].

From this comparison it is sufficiently clear how far off the intervals of the stars are, as set down by Gemma, even now, after correction — although one might suppose he had duly tracked them down with great and repeated diligence. Everywhere, moreover, he has spaces too cramped; and although in one place — at the end of the book, where he treats of the Observations of Hieronymus Munosius [Jerónimo Muñoz] — he tries to excuse this discrepancy by appeal to the depth of the eye [per oculi profunditatem] and to the disposition of the eye-socket placed around it, the discrepancy that this is apt to admit in the intervals when measuring across by the cross-staff [Radius] from the sky — yet this is in vain, since the parallax of the eye [Oculi Parallaxis] could in no way have introduced so great an aberration, especially in the smaller distances.

So too, as to what he intimated once and again about the Pole Star — that it was difficult to observe — there is no just reason for it. For why should it not be just as observable as the other stars, given suitable instruments, [in respect of] alignment [collimationi]? Is it because it describes a smaller circle around the pole? This surely poses no hindrance at all; indeed, if it were anything, it would rather advance the business. As for his claim that, with his father, he had with diligence always observed its distance from the pole as 3 degrees 35 minutes, so that the declina-

to the value of 86° 25', I am puzzled that he should say this, given that such a thing has scarcely happened in the past 100 years — a span his father did not live to see, and he himself far less so.

Moreover, Gemma also imputes this same observation to his father, Gemma Frisius [Gemma Frisius], with less justice. For in his *Booklet on the Catholic Astrolabe* [*Libellus de Astrolabio Catholico*] — which was the last of his works — the father pronounces quite differently about this star, asserting that it stood more than 40 years ago at 3° 8' distant from the pole, which differed as little as possible from the truth itself. But since this matter seems of some moment, I wish to set down here the very words of Gemma Frisius from the cited book, chapter 9. They run as follows.

In the year 1547, on the 13th of December, around the sixth hour of the evening, we carefully observed the greatest altitude of the fixed star that is in the tail of the Lesser Bear, which they call Cynosura, at 53° 58'. From this I subtract the elevation of the Pole at Louvain, which is 50° 50'. From this it follows that the star called the

Pole Star is distant from the pole by $3^{\circ} 8'$ — whatever others may write about it. I subtract this distance from the quadrant, and there remain $86^{\circ} 52'$. This is the northern declination of the Pole Star. I made the same trial the following day, the 6th hour of the morning of that same day, when this same star reached its least altitude in the north. I observed it at that time at about $47^{\circ} 43'$. If this is subtracted from the polar altitude, we shall again see the distance of the Pole Star from the pole as $3^{\circ} 7'$, and a little more — from which the same declination from the equator is also gathered.

Finally, let the least altitude, which was $47^{\circ} 43'$, be subtracted from the greatest, namely $53^{\circ} 58'$, and there remain $6^{\circ} 15'$. Half of this in turn comes to $3^{\circ} 8'$ or thereabouts, which is the distance of the Pole Star from the pole, as in what precedes — from which the same declination follows.

Thus that most excellent man, the elder Gemma, set forth concerning Cynosura quite differently from his son, and at that time he repeated this same altitude, both greatest and least, in the following chapter, so that there is no doubt that these numbers stand correctly according to his intent. For this reason I can scarcely conceive why Cornelius should have set forth values so dissonant from his parent's. I suspect, however, that through some carelessness with the cited passage it happened to him that, with 52 minutes adhering in the declination of the star, he carelessly seized upon 25 by a transposition of the figures; otherwise no excuse remains — though even this helps little in itself, since from the whole context it is gathered more than once that the distance of Cynosura from the pole was at that time over $3^{\circ} 7'$, or $8'$. By no means, however, was it $35'$, as he wished it here.

But that everything brought forward by the elder Gemma concerning the observation of Cynosura is sound, and corresponds well enough to the celestial standard for that year, our own observations in the same matter offer undoubted testimony, as we shall now show.

Since toward the end of this year 1589 the Pole Star is distant from the pole by precisely $2^{\circ} 54\frac{1}{2}'$, and since 42 years have elapsed since Gemma Frisius's observation — in the course of which those $14'$ necessarily diminished the declination and increased the distance from the pole — it must follow from our own observation as well that, adding those $14'$ to the figure for around the end of the year 1547, the distance from the pole comes to $3^{\circ} 8\frac{1}{2}'$. This exceeds his designation by at least half a scruple, or even,

if his observations are scrutinized down to the last with extreme nicety, by a single scruple — which is of almost no moment, and easily merits excuse, since the instrument with which he examined the altitude could scarcely afford an exact precision down to a half or a whole minute.

That we have said the accession of Cynosura toward the pole changed by 14' within these 42 years is confirmed as follows.

It was demonstrated in the Second Chapter that the fixed stars in these centuries traverse one degree in $70\frac{1}{4}$ years. Now Cynosura, given its disposition of longitude and latitude relative to the ecliptic, when it completes one degree of longitude alters its declination from the equator by about 24', falling short only by $\frac{1}{3}'$ — which from its place noted above will be easy to test by triangular computation. And so $70\frac{1}{4}$ minutes [recte: years] of declination change in about 24 years, and over 42 years 14' correspond proportionally. Hence the values I have just introduced are not incongruent with one another, and the elder Gemma's observations on the Pole Star support our own quite aptly — although the son applied them awry, with less skill in the inversion of the minutes.

These same things also agree with the annual accession of Cynosura toward the pole, which experience attests to be a third part of one minute, as we showed in the Fourth Chapter by collating several observations. Thus over every three years it approaches by one minute; and three such are contained in the 14 over 42 years — and so through experimental confirmation everything agrees correctly with the instrumental findings.

He next says that, by the Doctrine of Triangles, he found the place of the New Star in the same longitude as the star in the loins of Cassiopeia [Cassiopeia], and accordingly places it at 4° of Taurus — where, with only about six scruples short of three degrees, he anticipates the true position, yet the distance he makes from the pole, $28^\circ 15'$, he composed not too badly, falling short by at least two scruples. And so in its declination of $61^\circ 45'$ he agrees tolerably well, although the difference between the polar and the polar distance, by whose support he proceeded here, stands less than correctly. But since he makes the distance of the Pole Star from the pole too great, and that of the New Star from it too narrow, this faultiness is in a manner corrected by their conjunction.

Yet here I cannot refrain from pointing out how poorly this place assigned to the New Star by Gemma agrees with his own data. For when he establishes its declination at $61^\circ 45'$ and makes it culminate placed exactly on the colure of the equinoxes, touching the very beginning of Aries, its longitude can by no means be

referred to 4° of Taurus — but it will reach a position much closer than he supposed. In latitude, too, it will not stray far, as we shall easily prove from the appended figure, scarcely different from one used several times before.

For when, in triangle CBA, side AB is $23^{\circ} 31\frac{1}{2}'$ according to the interval between the poles of the ecliptic and the equator, and AC is $28^{\circ} 15'$ from the complement of the declination

Diagram. A circle representing a celestial sphere, with three points marked on or near its upper arc — A near the top, B to the upper right of A, and C within the circle below A. Several great-circle arcs are drawn across the disk, intersecting near the center; the principal triangle is CBA. The zodiacal symbols for Taurus (♉), Aries (♈), and Capricorn (♐ /Saturn-mark) appear around the rim, with a fixed-star symbol on the left. The figure illustrates the spherical triangle used to derive the New Star's longitude and latitude from its declination and the obliquity of the ecliptic.

- A (top): vertex A (pole of one circle)
- B (upper right): vertex B
- C (interior, below A): vertex C
- ♉ (left margin): Taurus
- ♈ (lower center): Aries
- $\text{♐} / \text{♄}$ (lower right): Capricorn / Saturn mark [?]

of the star. Furthermore, let angle BAC be a right angle, as is evident from the Elements of Spherics; therefore the third side BC comes out as $36^{\circ} 8'$, representing the complement of the latitude of the New Star, and angle ABC will be found to be $53^{\circ} 23'$, measuring the difference of longitude forward from the Tropic of Cancer. From these data, then, the longitude of the star falls at $6^{\circ} 37'$ of Taurus, with a latitude of $53^{\circ} 52'$. And thus Gemma, through these data of his own, produces a longitude greater by $2\frac{1}{2}^{\circ}$ than the one he presupposed, and arrives much nearer to its proper place, the one it occupied in the heavens itself — now falling short by only $17'$ as to longitude, whereas before he had deviated by almost three degrees. In latitude, too, the discrepancy from the truth is not very great, amounting to only $7'$.

Accordingly, what he says — that the greatest altitude of the star was $79^{\circ} 45'$ — can by no means stand together with the presupposed declination and the polar altitude of Louvain. For if to the complement of the declination, $28^{\circ} 15'$ (taken as the distance of the New Star from the pole), we add the elevation observed by his father with fair accuracy (as appeared from what precedes), $50^{\circ} 50'$, the star's

greatest altitude comes out as $79^{\circ} 5'$, falling short of his own statement by a good whole degree — which is indeed too much. And if its greatest altitude could be reckoned together with the star's declination at one and the same time, the polar altitude at Louvain would come out as $51\frac{1}{4}^{\circ}$, where by his paternal contrast he commits even an excess of $\frac{2}{3}$ of one degree. Perhaps he relied too confidently on the polar altitude which his father had recorded as $51\frac{1}{4}^{\circ}$ in the *Booklet on the Astronomical Ring* [*Libellus de Annulo Astronomico*], published long before — which the father at that time had not yet verified by observation, but had recorded as $51\frac{1}{4}^{\circ}$, or rather even some 12 years earlier, after the published opinions of others, less correctly. Otherwise, that this polar elevation which he noted there is less consonant is plain enough, since he attributes the same to Antwerp — whereas it is openly known that Louvain lies more than half a degree south of Antwerp.

And so from all this it is evident that Cornelius's annotations square correctly neither with one another nor with his father's observations, the difference being so great that it deserves no excuse.

He afterward compares certain of his own intervals with those of Hagecius [Thaddaeus Hagecius], and although both agree in the distance of the New Star from the Eleventh, they nevertheless commit a defect of nearly $7'$. Thaddaeus increased the distance of the Eleventh from the Pole Star by at least $8'$ too much, whereas Gemma there fell short by almost a whole degree, wanting at least $4'$. So too in the other intervals Thaddaeus came far nearer the mark than Gemma.

He next reasons about the parallax of this star; and although it was detected by some at three or four minutes, nevertheless he, having repeatedly

tried the same, confesses that he attained nothing certain. He nonetheless judges outright that there was none at all — and pronounces this quite truly — provided he had demonstrated it from equally sound observations, as was fitting.

But in that he excuses those who detected some small parallax on the score of vapors, especially at the morning hour for those facing the horizon, he does not act with sufficient circumspection. For those vapors would, through refraction, have made the star appear higher than it really was, and by no means lower. Therefore, the parallax, if there were any, would rather have been attenuated than increased. But it has been shown by us that this New Star, even in a lower position, was so exalted above the horizon throughout all Germany that it was liable to no perceptible fault of refraction.

It was therefore through carelessness of observation and of instruments that this star insinuated to some a parallax of a few minutes, where it was detected. It is therefore wrongly attributed to vapors — unless perhaps those vapors stirred up a mist in the eye of the observer rather than below the star, and so caused this parallax and impeded its accurate collimation.

Finally, he rightly gathers that this star was by no means below the Moon, nor even within the orbs of the planets, but that it remained — as he says — either in the Eighth Orb, or the Ninth, or the Tenth, perhaps even placed in some still higher one. In saying the Eighth, he pronounces not incongruously; for it stood altogether among the rest of the fixed stars affixed to the Eighth Sphere. But in adding the Ninth and Tenth and several more orbs, that is superfluous. He does this on the opinion of those who try to account for the motion of the Eighth Sphere and the universal revolution by certain other orbs superimposed above — but they have labored with vain effort, since there are in reality no solid orbs in the heavens, nor does one drag or impel another, as has falsely been believed by very many up to now, as we shall make more openly manifest in its own time and place.

What he afterward reports about the increase and decrease of the magnitude and light of this star does not agree in every respect. For this star was by no means smaller in November — so much so that it then matched at least Arcturus — than toward the end of December, when, he says, it equaled Jupiter in magnitude. In fact it was greatest of all in November, and at that time rivaled in its visible quantity not only Jupiter but Venus as well. And in December it began successively to decrease, which the observations of almost all others also attest. The rest, which he records about its gradual diminution all the way to the end of its extinction, holds tolerably well, and does not differ much from our own recording.

But as for his asserting that this star, in that place, increased from the beginning, just as it afterward diminished — contrary to what he reported in his first writing — this I gather to be probable rather from a certain plausible conjecture than from observation,

drew his firm conclusion. For he supposes that this star was higher at the beginning, then descended successively along a straight line until, brought nearer, it appeared larger, and that afterward, by ascending higher, it was gradually diminished. On this basis he does not hesitate to affirm that it could have been visible from the month of March or April of the year 1572, or even much earlier — because around the time the Sun entered Aries [♈] or Taurus [♉],

owing to the analogy of the place in which it must have begun, it would have vanished, and that in this way it persisted through two revolutions of the Sun. But he set out all of this without the testimony of observations and without any necessary inductive argument, far too arbitrarily.

For he is mistaken in his belief that the star was not made smaller by some consumption, but only by an increase of its altitude above the Earth and our eyes, ascending along a certain straight line. Granted that it underwent no motion or parallax by which this position could be overturned, still it is by no means to be conceded that any motion in the heavens takes place along a straight line. For that is utterly foreign to the perfection of the heavens, and can nowhere be attributed to them — unless it is compounded out of circular motions, in the way Copernicus [Copernicus] contrived in the case of the variation of the obliquity of the ecliptic and in the case of Mercury, although even so I would not grant that a strictly rectilinear motion is to be admitted among the heavenly bodies. And if this star had in this way descended from the highest recesses of the heaven into the eighth sphere [sphaera octava], and had afterward gradually raised itself up again until, through too great an elongation, it ceased to be seen — from where, I ask, did it come, and where did it go? And why do this star, or others like it, not descend and ascend more often, withdrawing themselves from sight? Let anyone consider how much space it would have had to traverse above the firmament before it became invisible: for when it was placed among the fixed stars, it equalled Venus [Venus] in magnitude, and in visible diameter it attained nearly four minutes; and before that visible magnitude could entirely vanish through excessive remoteness, many times more space would be required than there is from us all the way up to the eighth sphere. Thus the heaven would in the end run out into infinity by being enlarged. Nor does Gemma [Cornelius Gemma] here even agree with himself: for having first fixed the new star in the eighth, ninth, or tenth orb, or in some still higher one — would these orbs, then, which are imagined for this very purpose above all else, be present so very far above the eighth? And if the reality of the orbs were to be granted (a notion from which he does not shrink), how could this star have penetrated so many hard and impervious spheres over so great a journey? But let all that pass; none of it has any savor in keeping with the genuine nature and property of the star itself. For in truth it remained always in one and the same place; it neither ascended nor descended, but rather, in the very position in which it was generated, it was greatest from the beginning, and remaining perpetually in that same place, it was gradually diminished and consumed.

As for the fact that increases and decreases of light occur in the other wandering stars [Stellae Errantes] through their approach and recession, this has no bearing here, since that arises from their circular motion as they move now this way, now that — not from any straight line. Nor is anything of the kind to be ascribed to this star, since it remained perpetually fixed and unmoved.

Moreover, from the perpetual scintillation that accompanied this star for as long as it lasted, he proves that it had nothing in common with the elementary world or with the comets. And in this respect he reasons fittingly enough.

What he subsequently adds concerning the heavenly bodies and the comets, which appear in this or that magnitude around the horizon, belongs to optics, and does little or nothing to the present question.

Finally, in fixing the place of the star, he now considers that he has sufficiently discharged his task, and strives to make plain what this star was, to which order of prodigies it ought to be assigned, and for what cause it appeared to mortals. He rightly declares that it was not of the nature of the comets, nor to be put on a par with the one that stood for an entire year above Jerusalem [the Star of Bethlehem], and that it is to be reckoned neither a planet nor a fixed star coeval with the world. Thus he is not far from the mark in asserting that it was a metaphysical body, existing above nature, yet bound up with the motions of the heavens.

But the things he brings in concerning the angels, or even God himself (I shudder to report it) — in the form of a star, in its apparition, in its ascent and descent, and in a circular return proper to divine minds — are utterly impious, not to say blasphemous, since they feign that some visible creature was fashioned by the Author of the Universe with no reverence at all. But let these things be dismissed: they are unworthy of refutation. Nor again is it apt that he should liken this star to the one that appeared to the Magi; for that one was in truth in the neighbouring air, and the writer whom Nicephorus [Nicephorus] cites speaks of it more fittingly than Gemma interprets it. But the question of whether this new star had nothing in common with that of the Magi has been sufficiently debated by us in Chapter Three [Cap. Tertio]. For what he says — that if it had first stood in the air above Judaea, it could not have been seen above Persia, and that if it had afterward descended, it would have shown rather the appearance of some other exhalation in a place so far declined than the appearance such as the star was observed to have — is of no importance. For neither did this star, when it appeared to the Magi, stand above Judaea; rather it was first seen in the East, that is, in Persia (if indeed they came from there). Hence it is written, *We have seen his*

star in the East [*Vidimus Stellam eius in Oriente*], not "we have seen his star above Judaea." This star went before them toward Judaea, and then led them on to the house in which the boy Christ [Christ], whom they were seeking, was — which could in no way have happened if it had been revolving so high in the heaven, like this star with which we are now dealing, or like any other neighbouring even on the borders of the Moon's region.

He then more correctly asserts, from the influence and intermingling of the planets, that this star was not foretold or pre-signified, and so retracts what he himself had earlier affirmed in favour of this opinion. Yet that it had any agreement with the comet of the year 1556 — which he supposes on the basis of the analogy of the place from which the comet came and the place in which it disappeared — is utterly incongruous, as we have also said before.

Finally, he is anxiously occupied in unravelling the significations of this star, where he seems to indulge his affections somewhat too much; and he attempts to draw this star, displayed to the whole world, particularly toward the political affairs of the Belgians, as if there were nothing else going on in the world, or nothing else remaining to be done, than the things that are being tumultuously stirred up there. In the end he so far slips, in these dogmatic verdicts about the star, that he would attach the image of the crucified Christ to the star, and does not shrink, as it were, from crucifying him anew among the stars — and that too far too superstitiously, to say nothing more. So too he fashions swords and bows out of this new star and the neighbouring parts of Cassiopeia [Cassiopeia], thrusting some Vulcan, the craftsman of arms, in among the stars. But since these things are frivolous and of no moment, let them pass.

As for the Sibylline prophecy which he alleges — whether it makes anything to the point or not, I am unwilling to inquire just now. Perhaps that will be done more conveniently in another place. Nor will I add anything to the things he brings forward, theologically and astrologically, concerning the portent of this star, since (as I have said several times) it is foreign to my purpose.

He has more on these matters in the *Physical and Mathematical Apodeixis* which he wrote concerning the comet of the year 1577. There, not obscurely, he took certain things from the place in our published booklet that treats of the significations — transposing the words but not the substance — mixed in other matters from the same place, mingled some from the Sibylline writings, and disputes further about its nature and significations, which I have no wish to examine. By then Gemma had been better taught than before, that comets are generated in the heaven itself — though on the authority of Regiomontanus

[Regiomontanus] and Vogelin [Vogelin] he had undeservedly believed certain ones to be sublunar; but this belongs to his work on comets, which we summon under examination expressly in the following book, and so I pass over it here.

He adds at the end of his book on the characterism of nature the observations of Munosius the Spaniard [Hieronymus Munosius] concerning this star, and his opinions. But since we have not yet been permitted to inspect Munosius's own treatise, we shall weigh those things which Cornelius Gemma cites and adjudges from the same, directing our course from Belgium into Spain.

HIERONYMUS MUNOSIUS, the Spaniard

The most learned and most excellent mathematician Hieronymus Munosius [Hieronymus Munosius], professor of these disciplines and of the Hebrew language in the Academy of Valencia [University of Valencia], wrote about this star in the Spanish tongue; and what he set forth we shall note and examine according to the report of Cornelius Gemma.

He says he knows for certain that on 2 November of the year 1572 this star had not yet appeared — chiefly from the report of the shepherds, and because he himself, happening at that time to be showing his pupils the seats and names of the stars, did not notice it.

Although Cornelius Gemma tries to assert the contrary — namely that around the end of October this star was descried by some — nevertheless in this matter he rather follows a certain empty...

rumour of the common crowd than an experience worthy of trust. And Gemma here contradicts Munosius not only without warrant, but he even derogates from his own assertions published in his first writing, where he had asserted that this star was seen by no one before the ninth of November — so much so that on the eighth day it did not appear to the observers, the place of the heaven being clear and the air serene; indeed he did not hesitate to draw up a celestial theme [Thema Coeleste] for this very first day of its blazing forth, when the star was on the meridian, though there too he produced incongruous results. For it was also descried on 7 November by the Augsburg consul Hainzel [Johann Baptist Hainzel], as was noted before. And so Munosius more correctly asserted that before the second of November it did not exist — which also agrees exceedingly well with the things we probably set forth in Chapter 3 [Cap. 3]: namely that this star had its first beginning around the new moon celebrated on 5 November. And since Munosius was excellently skilled in mathematics, and surveyed the stars

with his own eyes, more trust ought to be given to him than to the rumour of the common people. Moreover, he too cites in his own favour the shepherds keeping watch by night under that milder Spanish sky. But Gemma preferred to hold the opinion that the star did not break forth suddenly in the magnitude in which it first appeared, but rather grew gradually by descending, and again was diminished by ascending — so that he might render it credible. But in what place these things are to be held, we have discussed before.

The observations of the distances made by Munosius, which he records, I shall here set down, with our own observations on the same stars also applied, so that it may be seen in how far they agree or not.

Distances of certain stars and of the new star, observed by Munosius, with our own also added.

Distances

Names of the stars	Munosius 's P.	Munosius 's M.	Our s P.	Our s M.	Differenc e P.	Differenc e M.
A. Seat of Cassiopeia [Sedile Cassiopeae]	5	20	5	19	0	1
A. Flexure [Flexura]	5	10	5	2	0	8
A. Schedir [Schedir]	7	50	7	50½	0	0½

It seems indeed that Munosius did not investigate these matters very scrupulously, since at any rate he everywhere noted the distances in whole tens of minutes; yet he hit the precise point more nearly than Cornelius Gemma, who deviated too far. Indeed, in comparison with the observations of Thaddaeus [Thaddaeus Hagecius] — which were far better collimated — he produced more accurate results in two stars, Lucida Cathedrae and Schedir: falling short here at least by half a minute, exceeding there by a single one, where Gemma as to...

falls short of this figure by 26 minutes, and short of the other by 15 minutes. In both cases Hagecius [Thaddaeus Hagecius] is off by at least 4 minutes. As for the value adjacent to those, although in the earlier *Dialexis* he had it about 11 minutes too small, he afterward corrected this distance so well that it now exceeds by at least a single second — whereas Muñoz [Jerónimo Muñoz] commits an excess of 8 minutes, and Gemma [Cornelius Gemma] a deficit of 26 minutes.

Muñoz's observations are therefore quite exact, and — with the single exception just noted — agree well with ours, departing only slightly from those of Hagecius.

Muñoz puts the maximum altitude of the New Star [New Star of 1572] in the horizon of Valencia [Valencia] at $67^{\circ} 30'$, and the minimum at $11^{\circ} 30'$, with the declination of the star at 62° toward the north. But he laid this out in too coarse a fashion: by means of a quadrant that was not large enough, since he uses only half-degrees. So it is no wonder that he increased the declination by nearly a fifth of a degree too much. From these figures he gathers the elevation of the pole at Valencia to be $39^{\circ} 30\frac{1}{4}'$ [recte: $39\frac{1}{4}^{\circ}$? — printed "r. $39\frac{1}{4}"$], which does not differ much from the geographical charts, although the tables of Apian [Peter Apian] and others disagree considerably on this point.

He fixes the longitude of this New Star at $7^{\circ} 48'$ Taurus, with a latitude of $53^{\circ} 36'$. Here, as regards longitude, he overshoots the true value by very nearly a full degree, coming closer by at least 6 seconds; while in latitude he falls short of what was required by 9 minutes. He likewise makes the culmination of the heavens occur at the first degree, 41st minute of Aries, where he commits an excess beyond the whole degree, and a fourth part of a degree on top of that.

It is likely, however, that Muñoz used neither the Alphonsine [Alphonsine Tables] nor the Copernican [Copernicus] positions of the stars; for otherwise, given the very distances he presupposes when those positions are assumed, he would not have pushed its longitude and right ascension so far beyond the legitimate bounds in the order of the signs. I therefore conjecture that he applied some peculiar method of his own in laying out the positions of the stars. To establish this beyond reasonable doubt, I am persuaded by a certain letter of his addressed to Dr. Thaddaeus [Thaddaeus Hagecius], a copy of which Thaddaeus once granted me at Regensburg. In it, when he had discussed certain points concerning the Copernican and Alphonsine motions — especially as regards the course of the Sun, which, he says, is closer to the truth from Alphonso than according to Copernicus (for in observing the pole-altitudes of very many cities in his survey of Spain, with the help of the Sun, he had often indeed followed Alphonso but more and more often imitated Copernicus) — he immediately adds these words:

Concerning the positions of the other planets and the stars, you will find in all of them manifest errors in their longitudes. As regards the star M. 51 [Margin: M.51], Copernicus is closer to the truth than Alphonso; yet Copernicus is off from the true place of the precession of the equinoxes by 27 minutes at the least. For the star that goes before in the horns of Aries, the year 1574 being completed, would according

to him be at 27° 50' Aries, whereas it is in reality farther on, at 28° 17' Aries. Test it, and believe no one.

So says he, word for word, in that same letter. From this it is plainly evident — just as I said — that he advanced the longitudes of the fixed stars more than was right. For when he says that Copernicus falls short by 27 minutes in the longitudes of the stars, he charges him with too great a deviation. As far as Spica Virginis [Spica] is concerned — the star he chiefly used in verifying the fixed stars — Copernicus committed a deficit of no more than a tenth of a single degree. But for that first star of Aries, not so much in imitation of Ptolemy's [Ptolemy] *Abacus* [Ptolemaic table], an excessive anticipation is inferred from Copernicus — or rather an excess. For although the place of this star in his system for the year 1574 is 27° 50' Aries, in the sky it then in reality stood at 27° 15' Aries, 35 minutes earlier. This is just as we deduced plainly from those matters which, in Chapter Two, we set out concerning the accurate restitution of the fixed stars, and it stands beyond doubt. In this part too the observations of the illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel], agree most closely with ours, being scarcely 6 seconds farther on as regards longitude. As for latitude, we agree within the same single second, indeed within half of it, since it amounts to 7° 8¼' — whereas the common reckonings have a fifth of a degree more.

Since Muñoz, then, advanced this first star of Aries by more than a whole degree, beyond the just limit, it could easily have come about (provided he likewise increased too much the precession of the equinoxes for the other stars he used in this nova, by his own standard, making them farther on than was due) that in this nova as well he overshot by nearly a whole degree. For it appears that just about as much excess is wanted in its greater elongation as the amount by which he hurries the precession of the equinoxes too far.

For supposing that anticipation of the equinoxes which he wanted — 28° 17' — the positions of the fixed stars he used will be, by the Copernican *Abacus*, of this kind:

NAMES OF THE STARS	Longitude (deg.)	Longitude (min.)	Latitude (deg.)	Latitude (min.)
Lucida Cathedrae	29	27 ♈ [Aries]	51	40
Schedir	2	27 ♉ [Taurus]	46	45
Flexura	8	17 ♉ [Taurus]	49	0

Accordingly, in the following diagram, let A be Lucida Cathedrae, B Schedir, and C the New Star. From the distances of this star from the two fixed stars observed by Muñoz, which we indicated earlier, and applying the procedure of Chapter Four with no trouble at all: first, in triangle A B E, the side B A will be $5^{\circ} 17'$, and the angle E B A $20^{\circ} 24\frac{1}{2}'$. Therefore in triangle B A C, the angle C B A is found to be $42^{\circ} 47\frac{1}{3}'$, and in triangle B E C the angle E B C comes out as $22^{\circ} 23'$ — that is, by subtracting angle E B A from C B A. Hence C E is $36^{\circ} 6'$, the complement of the star's latitude; and the angle B E C is $5^{\circ} 2\frac{1}{2}'$, which, added to the longitude of Schedir,

Diagram. A crescent-shaped (lunate) construction at the right of the page, used to derive the New Star's position by triangulation from neighboring fixed stars. The figure consists of two long curved lines sweeping down from an apex at the top to a base at the bottom, enclosing a sickle/crescent form, with two small triangles marked inside near the middle. The point letters are arranged as follows.

- L (apex, top): the topmost vertex, from which the two long curves descend
- A (middle-left, inside): vertex of the upper inner triangle (Lucida Cathedrae)
- C (middle-right): vertex to the right (the New Star)
- B (middle, just below A): lower vertex of the inner triangle (Schedir)
- F (lower-left): left foot of the construction at the base
- G (bottom): base point between F and H
- H (bottom-right): right foot of the construction at the base

yields the star's sought distance from the equinox, at $7^{\circ} 30'$ Taurus. With the latitude resulting from the complement just stated, it comes to $53^{\circ} 54'$.

The longitude found in this way, although it comes closer to Muñoz's view — who put it at $7^{\circ} 48'$ Taurus — is still 18 minutes smaller; and in latitude likewise an excess of the same number of seconds is found. For he wanted it to be at least 36 minutes beyond the whole degrees.

But if we weigh its distances from Flexura and Lucida Cathedrae in the same balance, and bring them into account, then by a complete triangular operation we shall find the longitude of the New Star to come out at $7^{\circ} 18'$ Taurus, with a latitude of $54^{\circ} 8'$ north. This departs still farther from Muñoz's position for the star, falling short by half a degree as regards longitude, and being a little more in excess as regards latitude.

It will therefore be necessary that he used yet other positions of the fixed stars before he could arrive at the position he assigned to the star. For if we apply the Copernican motion, the longitudes will come out nearly half a degree more anterior still; in the latitudes the ratio will be the same as before.

It is therefore not yet sufficiently settled how Muñoz predetermined the place of this star, since the distances from the neighboring fixed stars which he set down — however taken — do not assign that same place to it; indeed, if they are deduced from different stars, even ones verified to the very fineness, they will nonetheless not square with one another, nor exhibit the same place for the New Star. And so, since Muñoz himself has not given the grounds for the place he found, and since it does not emerge consistently from his own variously examined observations, we shall leave it at its own valuation, as something less carefully arranged, and discuss the rest.

In the same letter he compares certain of his distances with those of Thaddaeus, and although he sometimes proposes nothing absurd, his distances are nonetheless not always more on-target than Hagecius's.

For from the eleventh to the fourth, they are at least $3^{\circ} 35'$, where Muñoz says the interval is $3^{\circ} 50'$. Thaddaeus, in the corrected *Dialexis*, has $3^{\circ} 40'$, which indeed comes closer.

Diagram. The lower portion of the crescent construction described above, showing the base of the figure where the two long curves terminate. The base points are labeled, from left to right:

- F (lower-left): left foot of the construction
- G (center-bottom): base point between F and H
- H (right): right foot of the construction

So Thaddaeus correctly puts the twelfth and the eleventh at $4\frac{3}{4}^{\circ}$ very nearly, although Muñoz maintains they are at least $3^{\circ} 50'$ apart.

Likewise, from the second to the eleventh they are in reality $6^{\circ} 27'$, falling short of Thaddaeus's annotation by at least 3 minutes, while Muñoz has $6^{\circ} 50'$, an excess of 23 minutes.

Moreover, concerning the distance of Cynosura [the Pole Star / Ursae Minoris] from the New Star, which he himself fixed at $26^{\circ} 40'$, he is dealing with the same matter as Thaddaeus, supposing this value of his to be closer to the truth than the $25^{\circ} 30'$ which the latter wanted. But here Muñoz makes too large an excess. For Thaddaeus too was too great in this distance by about a quarter of a degree —

not, however, to the point of being deficient by a whole degree and a sixth part of it. For in reality the New Star and Polaris [Polaris] were $25^{\circ} 14'$ apart. There is therefore an excess of one degree and 26 minutes introduced by Muñoz, which, since it amounts to nearly one and a half degrees, makes it astonishing that he deviated so greatly. Likewise the distance of the Second [star] from Cynosura, which he alleges for himself and sets down in the same letter at $34^{\circ} 25'$, exceeds still much more, inasmuch as it is at [recte: short of?] $1^{\circ} 37'$. For the truest distance between these is $32^{\circ} 48\frac{1}{2}'$, as we noted in Chapter Four.

And so from these things it is sufficiently recognized that the radius [cross-staff / radius astronomicus] which Muñoz used was not in every respect correctly finished, so that the greater the distances were, the more they deflected from the mark. And although near the close of that same letter he says that he rendered Gemma Frisius's [Gemma Frisius] radius much more convenient for his own use, nevertheless whether it is more reliable for taking distances will have to be proved otherwise. For granted that someone, by the radius — whether in the way Gemma Frisius wanted, or by any other elaborated and subdivided device — should scrutinize the intervals of the stars to be exactly consonant with the sky itself, especially as regards the greater distances, he will scarcely find them; yet he will not be able to err by one and a half degrees or thereabouts, unless the radius itself labors under some great defect, or unless too much error is committed even during the observing. But enough of the matters contained in the manuscript letter. Now let me continue with those views which Cornelius Gemma published concerning Muñoz.

He says that by most careful consideration and by frequently repeated observations of this star he discovered no parallax in it — for which purpose he even drew up a remarkable table, from which he effectively proves that this star is higher than all the elements, indeed that it is placed in the heavens above the Moon ☾, Mercury ☿, Venus ♀, and the Sun ☉ — because, of course, the true place differs from the apparent place, at least in those bodies which are situated beneath the Sun. But on high, the line of the seen place and that of the true place always meet in one, as has hitherto been agreed by all and was demonstrated by Ptolemy. Most truly, therefore, did Muñoz pronounce this. For this star refused all parallax, and so was necessarily exalted far above the Sun — exactly as those matters are clearly demonstrated by us in Chapter Six. To these conclusions he subscribes excellently in this part as well.

He afterward adds, in this manner: *Finally the Author concludes that it is a certain comet, inhering in the heaven of the fixed stars, following in this part the opinion of Demo-*

[Margin: continues from the previous page] of Democritus, Anaxagoras, and Seneca — though he does not grant that it belonged to any of the kinds the ancients recorded. "For," he says, "it was neither a torch, which ought to equal the Moon in size, nor a rose," since it did not present the appearance of a human face but, as he thinks, an appearance peculiar to itself, of the kind that Lucan spoke of: "Through the dark nights the stars were seen unfamiliar."

Yet however much Gemma rejects the opinion that comets are assigned to the heavens by some of the ancient philosophers' imitation, it is nonetheless truer that comets are generated in the heaven itself, not in the elementary region. Those ancient philosophers — Democritus, Anaxagoras, and others before Aristotle, and afterward Seneca too — philosophized about comets far more correctly than Aristotle did, even though his authority has prevailed to the point that those who profess philosophy in the schools have generally placed more trust in him. And Gemma himself, in the comet that appeared five years later, recognized well enough that comets are generated in the heaven, and not always; so that what he had previously thought to be absurd was so no longer.

But whether this star is properly called a comet by Muñoz [Jerónimo Muñoz] — even though he does, not unjustly, affix it to the eighth sphere, supposing perhaps that comets sometimes appear not only in the orbs of the seven planets but there as well — whether that is appropriate, I would not say. For he seems to abuse the term "comet" far too broadly, applying it to every phenomenon newly received into the heavens. And although this could be conceded to some extent if interpreted favorably, still it is more properly to be called a star, because it turned out to be most similar to genuine stars, and had almost nothing in common with comets, except that it began at one time and afterward ceased to be. Nor did it have any tresses or beard, from which comets get the names *Crinitae* and *Cometae* ["the tressed" and "the bearded"].

I would rather suppose that comets move only within the bounds of the seven planets, from which they also derive a certain proper motion of their own; and so that they are a kind of pseudo-planet, though quickly consumed. But those new bodies that arise in the eighth sphere — which happens more rarely — I have judged are better compared with the fixed stars, and more fittingly named after them.

Cornelius Gemma [Cornelius Gemma] also argues from the twinkling of a star that this was not a comet, since comets never twinkle; and he brings this point in not inappropriately. And as for what Muñoz says — that there are also some comets without a tail — Gemma rightly concedes it, and indeed infers, still more rightly, that no histories teach of comets seen wholly without a beard and any emanation. The one we saw in the year 1585 did not, it is true, extend any tail that could be made out with certainty, yet it displayed all around certain little fringes like hairs, of a dimmer light, as appears in nebulous objects; and moreover it had a quite evident proper motion of its own, so that it deserved to be counted among the comets. But that motion, and any beard at all, were lacking in this star we are discussing; and it flickered a bright, radiant light like Sirius, which is not very aptly attributed to a comet.

These remarks about Muñoz may suffice. Had we obtained his whole treatise, it might perhaps have contained more matters deserving fuller examination. But content for now with these, by which the chief considerations (as I judge) of this star have been discussed, we shall move on elsewhere.

Yet before we leave Spain, we shall examine the opinion that a most learned philosopher, Francisco Valles [Francisco Vallés], who also lived there, brought forward in his learned book *De Sacra Philosophia*, published not long ago.

FRANCISCO VALLÉS OF COVARRUBIAS [FRANCISCUS VALLESIUS COVARRUBIANUS]

In that singular and industrious work, *On Those Things Which Are Written of in the Sacred Books Concerning Natural Philosophy* [DE IIS QUAE PHYSICE IN LIBRIS SACRIS SCRIPTA SUNT], Francisco Vallés discusses this star right at the beginning, in Chapter One. Although he is unwilling to admit that it was new — preferring instead that it was some small one of the old stars, illuminated so greatly through some denser part of the celestial orbs lying between, and on that account taken for new — so that it should rightly not be reckoned among those who handed down that it was truly new and had recently arisen in the firmament; nonetheless, since he admits that it had no parallax and that it stood in the eighth sphere, even though he alleges certain other causes for so remarkable a light, it will not be too out of place to look into his opinion here. And in order to do so more thoroughly and rightly, we shall set down here his very words from the said Chapter One of his book.

For after the matters contained in Chapter 18 of Ecclesiasticus — *He who lives forever created all things at once* — he goes on, from the beginning of the Second

Chapter of Moses [Genesis 2], *The heavens and the earth were finished, and all their array; and God on the sixth day completed his work, and then continues thus:*

By these words the opinion of certain astrologers can easily be refuted, who asserted that the star which appeared in the preceding year — the one thousand five hundred and seventy-third above one hundred — began to appear in the lap of Cassiopeia, and lasted through a great part of the present year, was new and newly created, and that Hipparchus was deceived no less, in supposing that he had detected a new star in his own age: which Pliny relates in Book 2, Chapter 2. For the whole array of the heavens would not have been finished, if the world had lacked that star until this century, and would now be defective, since it has ceased to appear. And so there would now be both creation and annihilation, whereas it is written in the Third Chapter of Ecclesiastes: I have learned that all the works of God endure forever.

But suppose that star had lasted less than a year. You will understand that the matter was indeed worthy of the greatest wonder, even from the opinions into which most learned men were drawn in their conjectures. For since they knew that no star of the first magnitude — such as it seemed to be — had ever existed there, yet it seemed that whatever it was that appeared was above the Sun, because it had no parallax, some affirmed that it was indeed a star, and a new one; while others (judging this more easily) held that it was a comet generated within the heaven itself, and that from this it is recognized that the heaven is not incapable of alteration, as is supposed.

But because this seems to me a very hard saying, and that other view altogether false, I judge that that star stood there from the beginning of the world and exists even now — only so faint that it cannot be seen except dimly — and that it was then seen to swell up to the first magnitude on account of some change in the intervening medium, which lasted so long. For since the parts of the heaven are not equally dense — as the Milky Way, the spots of the Moon, and the stars themselves indicate — it could have happened that this star, by the proper motion of the star itself, fell into some part of the nearer heaven that was denser than the rest, through which the denser light exhibited the appearance of a larger star; and then, passing on from there, it would seem to be smaller, just as now it sometimes seems faint and sometimes none at all, as happens with air. Thus all things were made at once, within the first week, though some before others, as I judge — not by nature only, but also in time.

In this way, then, Francisco Vallés philosophized about this star; but how incompetently and beside the point, we shall now see.

As to what he says at the outset — that the star began to appear in the lap of Cassiopeia — in this he shows that he had only modest knowledge of the fixed stars, and that he neither attended to this new one carefully nor rightly discerned much less what it was and by what means it came to be. For it was by no means in the lap of Cassiopeia, but rather outside the figure of the whole body, standing in solitude in the middle, toward the lower part of the back, not far from the loins. And so, in respect of its position — which lay open even to bare inspection — he was off from the true place in the heaven by about ten degrees, so that it is no wonder he went astray over the whole sky in the rest.

As to what he reports about Hipparchus — that he too was deceived, no less than the modern astrologers, in thinking that the new star sprang up in his own age — he pronounces too boldly and presumptuously about so great a master; as though Hipparchus, who undertook (as Pliny relates of him) to set out the places of all the heavenly bodies of the eighth sphere down to the smallest of the sixth magnitude, indeed to the nebulous ones, in a fixed scheme, could not have discerned better than anyone else between the old stars coeval with the world and any newly arisen one — by whatever means it might be supposed to be illuminated — but rather, on that occasion, undertook that immense labor, almost beyond human powers, of arranging each of the visible stars in its due place, only to fail to accomplish it.

So in truth Hipparchus did notice a new star, never before existing — just like this one too, which shone forth in our age; except that his was a moving one, while this remained fixed.

As to the objection Vallés raises — *that the whole array of the heavens would not have been finished, if the world had lacked this star until this century, and would now be defective, since it has ceased to appear; and so there would now be both creation and annihilation, whereas it is written in Ecclesiastes: I have learned that all the works of God endure forever* — here he interprets too rigidly and literally both the sayings of Moses and those of Ecclesiastes. For Moses speaks of the whole array of the heaven which God resolved to create all at once at the beginning, and which was to endure right up to the total consummation of the world. This array,

though absolute from the beginning, Moses did not on that account say that no bodies could ever afterward come to exist miraculously in the heaven, God bringing it about either mediately or immediately. For God's hand and power are never cut short, nor are laws prescribed to him. So too, from the beginning, he implanted in the Sun and the heaven a motion which by perpetual necessity he

would preserve as long as the machine of the world should last, together with an inseparable light; and yet, at certain times, the sun of Joshua stood unmoved for a while; the sun retreated for Hezekiah, king of Judah; the light of Christ's Passion was lost. And all these things were done miraculously, beyond nature. For God is not, in the opinion of the Stoics, bound by the laws of nature, as though the Creator were subject to created things — which would be unseemly — but rather the case stands the opposite way. Nor on this account was the whole array of the world less than perfect from the beginning, or is the world now defective, because this star has ceased to appear. For it did not belong to the primordial bodies that were required for the most perfect array of the world, but was adventitious and, as it were, accidental — so that the world could have been present even without it at its own time, and could likewise have lacked it, except insofar as, by God's special counsel, it was to be displayed, in the manner of a portent, to a world now tending toward its end. Those who pretend that this new star did not exist diminish too far the miracle of the wise and almighty God, and detract from the truth.

We see in this lower world that new generations not rarely come forth which were not there before, and again pass away, the period being completed. As for those words of Ecclesiastes — *that all the works of God endure forever* — they mean (so far as concerns the Creation of things) that those things which were formed from the beginning out of no pre-existing matter are perpetual and coeval with the world, yet not eternal, since at some point they began. They do not speak of secondary and miraculous works, composed anew out of some pre-existing matter. But of these we shall dispute more fully elsewhere; for it is not yet sufficiently settled whether this star was composed immediately by God himself, or rather by certain means, out of some pre-existing celestial matter — a question that will belong to another place. Nor is it to be settled in brief.

That the matter was supremely worthy of the wonder of the learned, because they knew that no star of the first magnitude had ever existed in that place, and because what they saw, lacking parallax, must necessarily be above the Sun — this he says rightly. For in truth this matter was supremely to be wondered at, and unfamiliar beyond the opinion of all men. For it did not attain even, as he would have it, to the visible size of the stars of the first rank from the beginning, but far surpassed most of them — so much so that it vied with the radiance of Venus in magnitude and the brilliance of its light. And it was altogether free of parallax, and exalted far above the Sun, and so into the eighth sphere. And those who affirmed it to be a new star brought forward what was in fact the case. But those who held it to be a comet generated within the heaven itself, and therefore that on this account the

heaven is not free of alteration (among whom was his own countryman Muñoz, of whom we spoke just now) — even though they apply the term "comet" not quite properly, but rather by misuse — [a most]

it is nonetheless most certain that true comets are formed in the heaven itself, just as I will set out in the books that follow, in full view, by means of unquestionable demonstrations. This will be so plainly evident to anyone who understands that no room will be left for any opponent to argue, to twist the matter, or to escape it. The earlier opinion, therefore, is not false; nor is this other view about comets unduly harsh — except in the eyes of those who have hammered out their philosophy in the workshop of Aristotle, who count nothing true and in accord with nature unless it is proved by his axioms, and who, blinded by a kind of prejudgment, suppose rather than know.

But in order to excuse so wonderful a spectacle on some grounds at least — lest the ruinous doctrine of the Peripatetics collapse altogether — this author imagines that the star was one of the ancient ones; that it had stood in that very place since the beginning of the world, and endures even now, but so faint that it can only be seen dimly. Then let someone with sharper eyes than a lynx point out to us even the smallest trace of any star in the place where this new one stood. Surely no one will detect anything of the kind there, even on clear winter nights, with stars twinkling and the very faintest ones visible, however pure the air. Antiquity counted thirteen stars in the constellation [asterism] of Cassiopeia, and among these there are indeed some so small that, unless one's sight is unusually keen and the sky quite clear, and the Moon is hidden, they can scarcely be made out. We have added thirteen more, very small ones, so that one might think they had been overlooked by the ancients. So if there were even the tiniest star, near the eleventh in magnitude, still surviving in the place where the new one stood, we would surely not have left it unobserved. For I deliberately examined, again and again and most attentively, in the purest clear weather, that same point of the sky where that new star had shone; yet not the least mark of any star appeared there once this one had ceased to be — just as, likewise, before it arose, nothing of the kind whatever could be seen in that spot, not even faintly.

But suppose we grant him that there is some star in that place, so small that it cannot be seen by itself — granting this to one who pleases to build up settled certainty, against his own Aristotle, about things that do not fall under the senses. Even so, his reasoning, by which this invisible little star could be made to produce so great an appearance, cannot stand by way of some intervening body or change. For even if we were to concede to him that the parts of the heaven are

not equally dense — as the Milky Way, the markings on the Moon, and the stars themselves to some extent show — given that nonetheless there are no real or solid orbs in the heaven, and that the heavenly bodies are not moved either of themselves or by the agency of Intelligences (as Aristotle held), but rather that the heaven itself is everywhere utterly clear and fluid, pervious in every part, with a power of self-motion divinely implanted in the stars themselves, which carry out their motion freely without the help of any solid spheres — given all this, the author pleads in vain for some celestial orb that worked the effect by the interposition of one of its somewhat denser parts. He labors fruitlessly to maintain one absurdity by another, where there is in truth no place for it at all.

[Margin: 576]

That the whole region of the heaven is entirely free of the orbs devised by Aristotle and certain others — so far as real and solid substance is concerned — I will amply prove toward the close of this whole work, in certain outstanding corollaries that necessarily follow upon, and depend upon, this entire treatment of the celestial phenomena according to the moderns. And even if nothing else established this, the comets themselves prove it well enough — and as the books that follow will make clear — for, without any just objection, they carry out their motions in the heaven variously and freely, bound to the accompaniment of no orbs. I say nothing of the refractions of the stars, of which the writers on optics [Optici] speak, which would rise all the way to the zenith if the heaven were composed of real diaphanous orbs, whereas in fact they scarcely reach half a quadrant in the case of the Sun, and barely so much as the smallest trace in the case of the stars — as is clear from what I have recorded in its proper place in Chapter One and Chapter Two [Caput Primum et Secundum], from accurate and manifold observations.

But even if we were to grant him this — that there are real celestial orbs, somewhat denser in some part — it still does not follow that this gives any way of excusing the star's unusual appearance. For if that part deserved [to produce such a star], it would surely happen not only in this case, where he imagines a tiny star, but also in others, larger ones, and would happen very often. For in so great a multitude of stars, and given the number and vastness of the orbs, if some of their parts were denser, they would make that star shine forth — or any other beneath them — and would now and then make it appear lit up more than usual; and this denser part of the orb, once it had passed beyond the star it was supposed under, would just as miraculously illuminate other neighboring stars in the constellation of Cassiopeia, or even behind it in Cepheus, and would make

them brighter. For however slow you suppose the motion of that orb which produced this effect to be, it must nevertheless, over so many ages of the world's existence, have passed beneath some star at least, in so great a multitude of them packed so densely together; and the denser parts would also be more numerous within the manifold vastness of the orbs, which would in turn from time to time augment certain stars of the firmament with light — yet no experience has ever taught any such thing. To wish to lay down anything contrary to experience is frivolous. Nor do I suppose that Vallés [Francisco Vallés] thought the part of the orb under which he places his fictitious little star had not always been inherent in that same orb beforehand, but had only then first arrived, and afterward dissolved, before passing under other stars. For if he thinks so, then, against Aristotle and against his own assumption, he attributes mutability to the heavenly bodies — the very thing he took the greatest pains to avoid.

There is also this further point. If that star which he supposes to lie hidden had increased its light and appearance through the supposition of a denser intervening medium, then surely, around the horizon, when it was lower, it would not have appeared in the same place as when it rose toward the zenith; for there it would have exhibited a perceptible refraction, which would have lifted it to a somewhat different position. But near the zenith...

[Margin: 577]

this difference would have been very slight, and almost imperceptible, because near the zenith the rays of the stars reach us directly, whereas near the horizon they reach us obliquely. For this reason — even if the optical reasonings alone cried out against it — this opinion of Francisco Vallés, however plausibly devised by him, cannot stand; and of the many other absurdities that go along with it, I will add nothing.

And so it remains, beyond all contradiction and beyond the quibbling of any evasion, that this star arose newly in the heaven, in that place where no other from among the perennial stars had ever stood before; and those who think otherwise do no slight injury to the heaven itself and to the truth of the matter.

The said Vallés has indeed, in that same work, brought forward much that is excellent, sharply and ingeniously, and not without diligence, in reconciling and harmonizing Sacred Philosophy [Physices Sacrae] with philosophy proper; and these things show plainly enough that the man is of great talent and industry, and well versed in the writings of very many philosophers — especially Plato, Aristotle, and Galen [Galen] — so that from this alone one may gather his

outstanding and manifold learning. Whether, however, he has hit the mark precisely in everything, as he supposes and tries to persuade us, I would not say. If he had drawn his instruction from the truer Physics and from the very Book of Nature — not so much the written one as the one offered to the senses and to external observation (which is especially analogous to the things cited from Physics in the Sacred Codices) — he would have brought forward conclusions more apt in most cases, and less doubtful, not fetched from so far off, and would have confirmed everything more firmly and clearly, relying not so much on the authority of the ancients as on the present inspection and experience of Nature itself. Nonetheless the study of that excellent man in this part is praiseworthy, in that he undertook to clarify a subject excellent and worthy of unfolding, one treated before him by very few; and he carried out what he set out to do (so far as one can tell) with such zeal and skill — even if he did not everywhere take aim at the mark he sought, and sometimes alleged a non-cause for a cause — by reason of that manner of philosophizing, hitherto less than complete in the Schools, which has been received, and which for the most part relies on the authorities of the ancients, whether what they said was false or true; and for this he deserves to be excused. For in great undertakings, the will alone is enough.

Now, then, leaving Spain — since no one else turns up there who has set down anything worth recounting about this star — I will sail back to Denmark, my homeland, drawing nearer to ourselves: namely, to what I myself committed long ago to certain little papers concerning this phenomenon, while it was still shining. These I shall revisit, and shall recall them to the anvil and examine them under no less mature a judgment than I gave to the views of others — so that what the physicians are wont [is accustomed] to say, "Cure yourself," cannot in this respect be cast at me by anyone.

TYCHO

[Margin: 578]

TYCHO BRAHE, the Dane, of Knudstrup [Tycho Brahe Danus de Knudstorp], Author of this Work.

I too had drafted some small pages about this very star, right from its very first beginning — and that not with the intention of ever putting them out in public. But while I was staying with the noble gentleman Steno Bille [Steno Bille], my uncle, at that time (as I noted at the very start of the Second Part [Secundae Partis]), I would write — to soften and relieve the weariness of the times and my distaste for the tedium of courtly life — among other things, the daily positions of

the stars, together with their risings and their various configurations, marking them for each single day; and likewise the principal constitutions of the conjunctions of the Luminaries [Zygiarum Luminarium], with their directions. I did this especially with this aim: to investigate what meteorological impressions [Meteorologicae impressiones] would arise in our latitude [Horizonte] from one and another disposition of the stars, and so, by experience, to perceive and note something certain about that knowledge of atmospheric changes which is in itself quite fluid and uncertain.

And so it happened that, while I was likewise compiling a certain Astronomical and Meteorological Diary [Diarium] for the year 1573 — and this strange star, having arisen most recently around the end of the preceding year, was still shining brightly enough — I judged it not inappropriate to work out geometrically some of the observations I had made of that same star, to resolve them into numbers, to attach them to that same Diary, together with my own assessment, such as it was, and my judgment about these things. And when, afterward, as spring approached, I had gone out to Copenhagen [Haffniam] as usual, to refresh myself a little there with friends and learned men, and to confer with them on various matters — among others, with that most distinguished and excellent man, most longed for by all, the learned Doctor Johannes Pratensis [Johannes Pratensis], of cherished memory (for not long after, in the very flower of his youth, he met his Day, to the great grief of very many) — I gave him that Diary, together with the things I had added about the New Star, to look over; for I lived on intimate terms with him beyond all others, being indeed his guest as well when I came to Copenhagen, and I took the greatest delight in his company. When he first heard me reporting certain things about this star, and had examined that manuscript book, he could scarcely persuade himself, out of his great astonishment, that some new phenomenon had arisen from the heaven — since the thing was unheard of and most unusual. For this marvelous spectacle had not yet become known to the people of Copenhagen, inasmuch as they were busy with something else at the time, and not attending to the heavens. But I added that, as soon as some clear evening light should shine, I would show it to him from the heaven itself, and that it really was so. And not many hours later, when that excellent and most honorable old man, Charles de Dançay [Carolus Dancaeus], legate here in Denmark of the Most Serene and Most Powerful King of the French (who not long ago, now an octogenarian, closed his last Day, and left behind him, in the judgment of all good men, the best of reputations and memory), from this...

and so passed over the horizon of time into eternity. He was, I say, a man of most illustrious memory, whom I had come to know as soon as I arrived in Copenhagen, having been invited there together with Pratense [Johannes Pratensis] by one of his household. While we were dining, I mentioned this strange new star to him as well, but at first he could not be brought to believe that anything of the kind could be seen up there. He thought I was joking — as if I were reproaching the people of Copenhagen for paying too little attention to the heavens, on the grounds that they could no longer tell the new stars in the sky from the old ones. At this Pratense broke in: "But why," he asked, "would Tycho have taken the trouble to write a special little treatise on this star if he had found nothing of the sort?" Dancey [Charles de Dançay], however, supposed that I had done it to pass the time, or to spur others to observe the heavens more attentively. Smiling, I answered that I would show him the very same thing that evening, if the sky should clear at all — that nothing strange to the heavens was being claimed, but that the matter was in earnest. And so I did.

On the way back to our lodging, when Pratense himself had several times caught sight of the star with me, blazing near the zenith, he at last burst out in great astonishment with these words: "Now I see it clearly enough with my own eyes — you are not playing a joke on me, my Tycho — and I see that what Pliny reports of Hipparchus is not so far-fetched after all: that he too observed a new star in his own age, even though all his interpreters wrest those words awry, twisting them to refer to some comet." For at that time he was lecturing publicly at the University of Copenhagen on the second book of Pliny's *Natural History* [Pliny, *Naturalis Historia* II], so that these passages of Pliny were fresh in his memory. Afterwards, then, fully convinced that the matter stood as I said, he gave credit to what I had reported about this star to others as well; and having surveyed more diligently the things I had set down — for he was excellently versed in mathematics and the other branches of philosophy — they did not displease him. On the contrary, he at once urged me to allow them to be made public.

But I, who knew well enough how hastily those notes had been put together, and how slight they were in proportion to the magnitude of the subject, and how, as it were, still unripe, refused his request. I added that I had written these things for no one else but only for myself, and that they were not polished enough to deserve coming into the hands of the learned. He, however, kept pressing me all the more. Yet he still could not obtain this from me. For at that time I was steeped in, and bewitched by, the prejudice commonly held by most men of noble rank — namely, that it does not befit one born of noble family to busy himself with anything in the scholastic arts, much less to publish it. So far indeed had the

corruption of vulgar manners and judgments prevailed, that I myself reckoned it unseemly to do anything beyond the customary practice of others.

And so, retiring into Denmark, I brought the little book back with me in manuscript, having resolved nothing at all about its publication. There at last — once, after I had returned from Germany, with spring coming on and free navigation again permitted, various opinions about this star had been brought to me, some in manuscript,

some in print — Pratense at once forwarded to me at my seat of Knudstrup [Knudstrup] whatever there was of them; for I had by then withdrawn there, girding myself anew for a journey through Germany and Italy — a journey which, however, was hindered that summer by an illness that came upon me. And so, having examined and read through carefully these judgments of certain Germans about this star — most of whom had made it out to be a genuine comet, some setting it 20, others 15, others at least 12 earth-radii [Semidiametri Terræ] distant from the earth, so that it stood in the neighboring air and, as they supposed, blazed there — I was sufficiently assured by my own indubitable observations that the matter stood far otherwise, and that this star had shone forth in the highest aether, free of all parallax. I therefore turned away from these absurdities and rejected them, and began once more to gather up, and to value more highly than before, those notes of mine which, on account of their slightness and immaturity, I had nearly come to disdain — and not to throw them away entirely among useless scraps.

And when I had again run over to Copenhagen for the sake of inspecting certain works that I was having made at the craftsmen's shops, that excellent Pratense did not even then leave off urging me to permit that little writing to be published. And to persuade me the more readily, he arranged that I should be asked, in his own name as well, by that most distinguished and most noble man Peder Oxe [Petrus Oxonius / Peder Oxe], Lord High Steward of our realm, who at that time stood foremost in dignity and public office at the royal court of Copenhagen. Oxe likewise advised, interposing his own authority, that it would be no dishonor for a nobleman to publish something in the liberal sciences. Indeed, he added in all seriousness that, if I so shrank from having my name attached, I might allow the work to be printed under an assumed name, or with an anagram of my name inverted.

But I, well aware that the writing was altogether too thin and not worked up to its finest polish — as far as I had been able — still set my face against publication, yet in such a way that I told them I would deliberate on the matter for Oxe's sake.

After I had returned to Knudstrup and was making all my preparations for the journey, Pratense pressed me by letter to grant what he had been unable to obtain before in person; and once I had read his letters, I was at last brought round to his view. I sent him whatever little commentary on this star I had drafted, together with the entire Diary [Diarium], and granted that everything should be done or left undone at his discretion. He soon handed the little book over to the printer, and saw to it that what I had noted there about this star — together with some matters that could not conveniently be committed to print (for many of them were filled with numerous diagrams [Schematismi], so as not readily to admit of printing) — were printed along with it. And so that it might be clear on what occasion that little book had appeared, and why it had come into the public domain so late, he prefixed his own letter — the one by which he had at last won from me the concession of publication — together with my reply and consent.

He set this at the head of the writing — two such letters, in fact, which we shall also report in our volume of *Astronomical Letters* [Epistolarum Astronomicarum volumen], so that this matter, and what they contained, may be more fully known.

I had indeed intended, once I was already inclining to allow its publication, to revise that writing — at least so far as concerns this new star — and to bring most of it to a more polished and solid finish. But since I was then preparing for a long journey abroad, and was being repeatedly visited by friends and noble kinsmen before the departure I was contriving (more frequently than usual), I was forced to break off all revision and correction. Hence it came about that the writing was published at Copenhagen as a kind of abortive thing, never brought to its final polish.

I noted at least briefly in the margin what, in the time since I first composed those pages, I had observed in that star afterwards, right up to the beginning of May — about which time I sent off the little book, so that those notes might be inserted along with the rest; and so it was done. Nor can I deny that I sometimes regretted that publication — not because I was uncertain whether the things it contained held good in their principal part (for as to the chief points asserted there I had no hesitation), but because, given the grandeur of the subject it treated, it was not in all its parts elaborated clearly and solidly enough — especially since certain matters of no great importance, a mere medley, were tacked on from that same Diary.

I have recounted somewhat more fully the occasions of the little book formerly published about that new star, so that it may be clear that it was not composed of any set purpose or deliberation that these things should be made public. And therefore let the fair-minded reader, if he finds anything defective and incomplete, not brought to its final polish, interpret it the more kindly.

But in fact it is my intention now at last to revise this commentary, slight as it was, then published about this star, to inquire into its contents, and to call them back to a more accurate weighing. And so that this may be done the more conveniently, I shall here append the writing itself word for word, in its larger and principal part. For few copies of it were published, and far fewer reached foreign readers (owing to a certain stubbornness on the printer's part).

A Mathematical Reflection by the Author on a New Star, Never Seen in the Memory of Any Age, Never Beheld since the Beginning of the World, Which First of All Appeared at the End of the Year 1572 — as it was published at Copenhagen, while the star still endured at that time, by the most renowned and excellent man, D. D. Johannes Pratensis (of blessed memory)

In the preceding year, in the month of November, on the eleventh day of that same month, in the evening after sunset, when I was contemplating the stars in a clear sky according to my custom, I noticed that a certain NEW and unusual star, conspicuous beyond all the others, was shining near the vertex of the head [near the zenith, by Cassiopeia]. And since I — who from nearly my boyhood have known all the stars of the sky perfectly (for there is no great difficulty in this science) — was sufficiently certain that no star had ever before existed in that place of the sky, not even the smallest, much less one of such conspicuous brightness, I was led into such great wonder at this thing that I did not hesitate to doubt the trust to be placed in my own eyes. But when I observed that others too, once the place was pointed out, could perceive that the star was really there, no doubt remained for me any longer.

This is surely, among all the wonders that have come to pass in the whole of nature since the beginning of the world, either the greatest, or certainly one to be ranked with the greatest — second only to that miracle of the staying of the Sun's course, obtained at Joshua's prayers, or its darkening at the time of the Heavenly Victim [the Crucifixion], as the Sacred Oracles attest.

For it is established among all philosophers, and the thing itself plainly declares, that in the aetherial region of the celestial world no alteration of generation or corruption takes place; rather, the heaven and the aetherial bodies contained in it neither increase nor diminish, neither vary in number nor in magnitude nor in light, nor in any other respect, but always remain the same and like to themselves in all things, with no wasting years.

Moreover, the observations made by all practitioners over the several thousand years now elapsed bear witness that the stars have always kept the same number, position, order, motion, and quantity — just as, in our own age too, they are seen by those who take delight in celestial matters to keep them, when careful observation is made. Nor do we read that a new star was ever observed by any astronomer to have existed in the celestial world before — except by Hipparchus alone [Hipparchus], if Pliny is to be believed. For Pliny is the authority that Hipparchus observed a star, different from all those noted before, born in his own age, in the second book of his *Natural History* [Pliny, *Naturalis Historia* II]. Since his words, here as elsewhere, are striking and magnificent, I have thought it not out of place to set them down here. "That same Hipparchus," he says, "never sufficiently to be praised — than whom no one has done more to prove the kinship of the stars with man, and that our souls are a part of heaven — discovered a New and other star, born in his own age. Moved by its motion, on the day it shone, he was led to the doubt whether this might happen more often, and whether those we call Fixed also move. And he likewise dared a thing reproved even by God: to number the stars for posterity, and to mark out the heavenly bodies by a standard, devising instruments by which he might note the places and magnitudes of the several stars, so that from this it might easily be discerned not only whether they were passing away or being born, whether too they were growing or diminishing — heaven being left as an inheritance to all, should anyone ever be found who could grasp that reckoning."

Although those words of Pliny [the Elder] testify clearly enough that Hipparchus did discover a true star, born in the aethereal region in his own time, and that on this occasion he marked the positions of all the rest with the proper instruments (something no one had done before him), so that posterity might learn whether

this could happen more than once — nevertheless Milichius, the interpreter of Pliny, did not hesitate to twist that passage into the appearance of some comet, in defiance of the improbability of the thing and against the judgment of all philosophers, dragging the author's plain meaning that far off course. As for how perversely he has interpreted this passage of Pliny about a comet, no one who has carefully examined the words he cites will dispute it. For how absurd is it, I ask, to claim that Hipparchus — a man outstanding in every branch of learning, and among others the greatest master in mathematics — did not know how to distinguish the true stars of the aethereal region from the fiery meteor of the air which they call a comet? And how absurd to claim that he would rather, on the occasion of such a comet, leave posterity a catalogue and the positions of all the fixed stars, a work of divine rather than human labor! I pass over how ridiculous it is that this same commentator on Pliny asserts, from the words just quoted, that Hipparchus detected the positions and motion of the fixed stars by the motion of that comet — for he supposes this star to have been a comet. Yet the course of every comet is irregular, unstable, swift, and wandering, whereas the motion of the stars in the eighth sphere [octavus orbis] of the fixed stars is regular, fixed, uniform, and so slow that in the whole lifetime of one man it can scarcely be perceived to advance at all.

I mention these things from no desire to find fault. For it is not the mark of a candid and generous spirit to belittle the labors of others by disparaging them; I only wished to warn against having learned men, relying on the authority of this interpreter, twist Pliny himself into the appearance of some comet rather than of a true star. To me at least there is no doubt that by these words Pliny meant that Hipparchus had discovered a true and genuine star, then for the first time born in the sky in his own time. Otherwise neither would Hipparchus himself have reported anything new, or worthy of admiration, about so great a man, nor would such a thing be noticed by anyone with even a smattering of mathematical knowledge — given that comets are seen rather often. But what and of what kind that star was, and whether it again vanished or not, we leave in doubt, since it cannot be gathered from Pliny's words.

Nor do we read that anything similar was observed by any astronomer, either before the time of Hipparchus or even afterward, in the now seventeen hundred years that have elapsed, as I have often said — though it is known — before, in our own age, that star of which we now treat began to be seen. And that this star was not in the elementary and airy region of the world, nor some apparent fiery meteor, but held its place among the celestial bodies, we shall demonstrate later.

It is therefore clear how unusual, how marvelous, and finally how incredible to all philosophers this matter is — that a new star, different from earlier ones, has now at last appeared in the sky. Nor do I think it possible even for the theologians, who are accustomed to excuse many other things that happen miraculously in the worldly sphere by appeal to divine mysteries, to assign sufficient causes for this event. For by the history of Moses on the fabric of the world it is established for them that God, the Author of the universe, after he had completed the heavens and the elements with all their adornments, rested from all his work and afterward created no new species of things.

I know, however, that some, drawing upon a more hidden philosophy first brought to light in our own age, will maintain that it is possible this star lay hidden until now in the ancient Iliad [*ueteri Iliado*] (for I am willing to use their own terms), and has only now at last, with its maturation complete, come forth to be seen by mortals. And although I will not now dispute about the certain or ambiguous foundations of this new (as it is held) philosophy, and although I am not unaware that

from it the causes and origins [*progressus*] of many abstruse things in nature, either unknown to common philosophers or less correctly understood by them, can be explained — nevertheless it scarcely seems probable to me that this miracle can be adequately accounted for by that reasoning. For if generations of this sort took place in the sky (which they do not hesitate to call the fourth and fiery element, on the strength of their own reasoning), why has it been observed that a new star has come forth, after so many ages have passed, in such a vast expanse of the heavens? And why are those things that have appeared up to now perceived to have undergone no alteration in magnitude, light, color, or order from the very beginning of the world? If that were so, in so great an interval of time, and amid so great an abundance of stars, there would have to be such a necessity of generation and corruption befitting a sky of that kind.

Let all the philosophers therefore fall silent, whether the ancients or the moderns; let the theologians too, interpreters of the divine mysteries, fall silent; let the mathematicians, contemplators of the celestial bodies, fall silent — none of whom, I judge, can establish anything certain either about the manner of this star's generation or as an excuse for so great a miracle.

Nor should anyone persuade himself that this star is like the one which appeared to the Magi of the East when the Savior of the world was born. For that one was not in the sky among the other stars, but held its place in the lowest region of the air, not far from the surface of the earth. Otherwise it would not, by its own

motion, have shown the way to those seeking the Savior, nor by its rest have shown the house in which he was to be found. But had it been carried around with the whole heaven, it would not, with respect to the earthly globe, have had so small a span of space — since the whole earth, compared with the heaven, has no magnitude that strikes the senses. Add to this that the star of the Magi was seen setting out from the east, so that, coming to adore the Lord, they might offer him gifts of gold, frankincense, and myrrh, as to a king, to God, and to a man — whether because God specially enlightened their minds and eyes, so that, coming from a far and unknown region, they might recognize him through whom all things were made to have put on human nature, whom the Jews themselves, among whom he was born, did not know; or whether these wise men, by a more hidden and recondite knowledge of magic, that is, the art of investigating things, perceived and understood what the rest, ignorant of this science, did not — whence not without reason they had obtained the name of Magi in the Sacred Scriptures. But what kind of star that was, which appeared to them, is not the place to investigate too scrupulously, since even the theologians, owing to their ignorance of that excellent magic, establish nothing certain in the matter. For it is enough to have shown that this new and unusual star which lately appeared has no kinship with that one which was seen by the Magi, since the manner of its generation cannot be accounted for either by the theologians or by the philosophers, nor even by the mathematicians themselves.

It remains, therefore, that we set it down as a token of God, the Maker of the whole machine of the world, to be marveled at — beyond all the order of nature, established by himself in the beginning and only now displayed to a world growing toward its evening. For the Divine Majesty acts most freely, and is bound by no chains of nature, but when he wills, he halts a river in its course and turns the stars backward:

This power could check the racing chariots of the Sun, When Joshua, the leader of the people of Israel, laid the enemy low. This power could quench the Sun's light without the Moon, When his own Son was made a victim for us.

Therefore, although I have resolved to bring forward something here in the open about this new star, now born for the first time, I freely confess that I can affirm nothing about its generation or by what causes it came to be; only those things which pertain to mathematical consideration I shall examine. For I shall speak of its position with respect to the longitude and latitude of the fixed stars and of the zodiac, of its distance from the center of the universe, that is, from the earth, and

also of its magnitude, light, and color — to which I shall add as well the conjectures drawn from astrology concerning the effects of this star.

ON THE POSITION OF THIS NEW STAR IN THE SKY WITH RESPECT TO THE FIXED STARS, AND ITS LONGITUDE AND LATITUDE WITH RESPECT TO THE ZODIAC.

This newly born star was seen in the northern quarter of the sky, toward the Arctic Pole [North Pole], near the constellation which the ancient Magi called Cassiopeia — close to that small star which is in the middle place of the Chair [Cathedra], a little removed from it toward Cepheus. It also formed a quadrilateral figure with the topmost star of the Chair, with the one called Schedir in the breast, and with the one that lies along the bend toward the thigh [Ilia]. But that the whole matter may be better understood, I shall set before the eyes the principal stars of the constellation Cassiopeia, together with the position of this new star relative to them.

Diagram. A rectangular bordered figure showing the principal stars of Cassiopeia (drawn as small radiant star-symbols), with the new star marked among them. Inside the frame, lower left, is a legend keying nine labeled points [A–I].

Star positions within the frame (as drawn):

- G (upper left): Suprema Cathedra [the topmost star of the Chair]
- A (upper right): Caput Cassiopeae [the Head of Cassiopeia]
- B (upper middle, below A): Pectus Schedir [the Breast, Schedir]
- C (middle, below B): Cingulum [the Girdle/Belt]
- H (left of center): Media Cathedrae [the Middle of the Chair]
- I (left, beside H): Noua Stella [the New Star]
- D (center): Flexura ad Ilia [the Bend toward the Thigh]
- E (lower center): Genu [the Knee]
- F (lower left, on the frame): Pes [the Foot]

Legend (as printed, lower-left inset):

- A Caput Cassiopeae [Head of Cassiopeia]
- B Pectus Schedir [Breast, Schedir]
- C Cingulum [Girdle]
- D Flexura ad Ilia [Bend toward the Thigh]
- E Genu [Knee] F Pes [Foot]

- G Suprema Cath[edra] [Topmost of the Chair]
- H Media Cathedrae [Middle of the Chair]
- I Noua Stella [the New Star]

The distance of this star from certain fixed stars in the constellation Cassiopeia I observed many times with an exact instrument capable of measuring all the minutes. I found it to be removed from the one in the Breast, called Schedir [B], by 7 degrees and 55 minutes; from the bright one in the Seat [Sella], G, by 5 degrees 21 minutes; and finally from the one along the bend toward the thigh, D, by 5 degrees 1 minute. From these distances of this new star from the said fixed stars, its place fell out so as to be at longitude 7 degrees of Taurus [♉], with a northern latitude of 50 degrees, with very few minutes neglected on either side; and this became known chiefly through the two last intervals, namely from the Bend and from the topmost of the Chair. For if the positions of these fixed stars, in longitude and latitude, are noted, the longitude of the new star from the vernal equinox, and its distance in latitude from the ecliptic, will not be hidden from anyone skilled in the science of spherical triangles.

For the sake of a clearer demonstration, let two fixed stars of the constellation Cassiopeia, A and B, in the following figure, represent — A, the one in the upper part of the Chair, which others place in the middle of the ascension; and B, the one which is in the Bend, near the thigh. Let C be the place of the new star; AC the arc of its distance from the topmost of the Chair; CB the arc intercepted between this one and the Bend; and AB the arc of the interval between the two fixed stars. Let G in addition be the northern pole of the zodiac, from which let two quadrants descend to the ecliptic through the aforementioned fixed stars placed at A and B — through A indeed GD, and through B GF. Therefore DF will be the arc of the ecliptic dividing the longitude of the two fixed stars, and AD and BF the arcs of the latitudes of the same fixed stars. By like reasoning, from the pole of the zodiac, through the place of the new star set at C, let a quadrant be drawn to the ecliptic, which here will be GE. Therefore E will be the place of the longitude of the new star, and DE the portion of the difference of longitude of this star from the prior fixed star set at A. CE indeed is the arc of latitude, that is, of the star's distance from the ecliptic. Now let the places of longitude and latitude of the fixed stars be assumed such as the Table of Copernicus [Copernici Abacus], with the precession of the equinox added, indicates — so that the longitude of the prior star A is at 29 degrees 0 minutes 0 [seconds] of [Aries], from the

vernal equinox, and at the point D, with a northern latitude of 51 degrees 1 minute 40 seconds, which (as I said) the arc AD represents. The longitude of the

latter star set at B is at 7 degrees 50 minutes 0 [seconds] of Taurus [♉], and at the point in the sign F, with a northern latitude of 49 degrees 0 minutes 0 seconds, which the arc BF designates. From this, I wish to investigate the arc DE, namely by how much E, the longitude of the new star, exceeds the longitude of the fixed star set at A, which is at D, so that E, the place of the longitude of the new star, may be known on the ecliptic; and likewise to investigate the quantity of the arc CE, so that the distance of this new star from the ecliptic, which they call its latitude, may also become known.

Diagram. A spherical-triangle construction in the right margin, spanning pp. 585–586. From an apex G (the northern pole of the zodiac) two long arcs descend. Near the middle a small triangle is formed by points A, C, and B (the prior fixed star, the new star, and the latter fixed star). At the base lie the ecliptic points D, E, and F.

- G (apex, top): the northern pole of the zodiac
- A (left, mid-figure): the prior fixed star (upper part of the Chair)
- C (between A and B, slightly above): the new star
- B (right, mid-figure): the latter fixed star (in the Bend, near the thigh)
- D (lower left, on the base/ecliptic): foot of the quadrant GD through A
- E (lower center, on the base): place of the longitude of the new star
- F (lower right, on the base): foot of the quadrant GF through B

But that we may arrive at the knowledge of these things by the proper procedure through the science of spherical triangles, I first consider the triangle AGB, of which the two sides joined at the pole G are known — through the complements of the latitudes of the fixed stars: GA, namely, 38 degrees 20 minutes, and GB, 41 degrees 0 minutes. There is also an angle which the said sides comprehend that is known. For the arc DF measures it, namely the difference of longitude of the two fixed stars, which is 8 degrees 50 minutes. Hence, by the twenty-eighth Proposition of the Fourth Book of Johannes Regiomontanus [Regiomontanus] *On Spherical Triangles*, the arc AB becomes known, which we find to be 6 degrees 14 minutes — the same as I observed through the instrument as well, by taking the distance of the two fixed stars. Thus the said triangle AGB now has all its sides known; whence, by the last Proposition of the Fourth Book of Regiomontanus *On Triangles*, or by the thirteenth of the Fifth Book of the same, and by the thirteenth of Copernicus on the same matters, the angle BAG will be made manifest. I have found this angle, by the exact operation of the numbers, according to the said Propositions, to be 111 degrees 51 minutes.

Now likewise, by the same reasoning, I shall measure the angle of the triangle CAB, which is at A: for all the sides of this triangle are known from what precedes — CA being 5 degrees 21 minutes, CB 5 degrees 1 minute, AB 6 degrees 14 minutes. The angle CAB therefore comes out, by the said Propositions, to be 50 degrees 42 minutes. Subtracting this angle from the angle BAG previously found, as a part from its whole, there is left the quantity of the angle CAG, 61 degrees 9 minutes.

Now I proceed to the triangle CAG, whose angle, which is at A, has now become known to me. The two sides comprehending the said angle, GA and AC, are known from the foregoing. Therefore, by the benefit of the 23rd Proposition of the Fourth Book of Regiomontanus *On Triangles*, the remaining side GC becomes known, namely of 36 degrees 10 minutes. Now the arc GC was the complement of the latitude of the new star. Whence, when this is taken from a quadrant, the true latitude of the star comes out, namely 53 degrees 50 minutes: that is to say, the quantity of the arc CE.

To investigate the longitude of this star, I inquire into the quantity of the angle DGE through all the sides of the triangle GAC, now known, according to the Operation of Proposition 34 of the Fourth Book, or the thirteenth of the Fifth Book of Regiomontanus *On Triangles*. I find the said angle to be 7 degrees 59 minutes. Now this angle is measured by the arc DE, representing the difference of longitude of the new star from the longitude of the prior fixed star. Therefore, by adding this arc of (as I said) 7 degrees 59 minutes to the longitude of the prior fixed star which we assumed, namely 29 degrees 0 minutes 0 of [Aries], the place of the longitude of the new star comes out at 7 degrees of Taurus [♉] complete, with at least one minute to spare, having a latitude from the ecliptic of 53 degrees 59 minutes, as found above — which was to be demonstrated. And thus

By this method, then, we have investigated the longitude and latitude of this new star, relying on the infallible procedure of the doctrine of triangles. But I will not lay out the full course of the operation — the inquiry into the angles and sides of the various triangles already mentioned, with reference to the cited propositions of that doctrine — partly because it would be too long-winded, and partly because the whole business would become excessively involved if treated here in full. Indeed, a good part of the propositions of Regiomontanus's [Regiomontanus] Fourth Book is taken up in this work, since all of them, in the geometrical manner, hang together in a chain. And besides, the knowledge of spherical triangles is too divine and too excellent a thing for me to be entitled to divulge its mysteries lightly.

I am of course aware that the positions of the stars of the eighth sphere [sphaera octava] are not yet known with sufficient precision. From this it could happen that the fixed stars I have used as the foundation of this demonstration do not have exactly the longitude and latitude I have assumed for them, so that the place of this new star might perhaps have to be set somewhat differently. Yet because I myself have so far made no certain observation of the positions of these fixed stars, I have been unwilling to depart from the catalogue of Ptolemy [Ptolemy] and Copernicus [Copernicus]. I prefer to follow them rather than the Alphonsine medley [Alphonsina farrago], because repeated observation has taught me that Copernicus's figures come closer to the heavens than do the Alphonsine ones or any other tables of the celestial motions. I am confident that the place of this star assigned by me, found with the help of the fixed stars I have assumed, does not stray far from the truth. And if God prolongs my life, I will see to it that the positions of the fixed stars, corrected one day from my own observation, are made public for the common benefit of astronomers.

From the longitude and latitude of this new star thus found, I have also worked out its declination — that is, its least distance from the equator — by means of spherical triangles, and have found it to be 61 degrees, 59 minutes. By instrumental observation conducted directly by eye I have likewise found it to be of exactly this magnitude. By the same procedure, from the known declination and longitude, I have determined its right ascension to be 0 degrees, 17 minutes, very nearly. Hence this star culminates — passing nearest the zenith — together with 19 minutes of the first degree of Taurus, and with the same amount of Scorpio it again crosses the meridian, this time near the horizon. Its place therefore very nearly coincides with the circle called the colure of the equinoxes [colurus aequinoctiorum], and lies near the boundaries of the Milky Way, between Cassiopeia [Cassiopeia] and Cepheus.

It stands at the vertical point for those places on Earth that have the elevation of the arctic pole at about 62 degrees, for such (as I have said) is the star's declination. And this, I judge, is sufficiently stated and demonstrated concerning the position of this new star — both with respect to the fixed stars and to the ecliptic longitude, and with respect to the equator itself.

It has kept this position the whole time, from when we first caught sight of it, and (by diligent observation made over and over again) it has not moved from it by so much as a minute. For this reason I venture to predict that in time to come it will likewise remain in the same place, and will move by no proper motion of its own other than the common motion of the fixed stars, in the eighth sphere.

ON ITS SITUATION WITH RESPECT TO THE DIAMETER OF THE WORLD, AND ITS DISTANCE FROM THE CENTRE OF THE UNIVERSE.

It is an arduous task, and one that demands subtle intelligence, to track down the remoteness of the stars from us, on account of their incredible distance from the Earth. There is no more convenient or surer way of accomplishing this than by parallaxes [parallaxes], if a star admits of being measured at all. For if some star near the horizon is seen in one place, and again where it approaches nearest the highest point of the zenith, it must be found in some orb with respect to which the Earth has a perceptible magnitude. But the farther off the said orb is removed, the smaller will the parallax show itself to be, once the quantity of the parallax is compared with the semidiameter of the Earth. On the other hand, if a star, whether near the horizon or near the zenith, is observed from the same point of the first mobile [primum mobile], there is no doubt that it has its place either in the eighth sphere, or not far below it, in an orb with respect to which the whole Earth acts as a mere point.

So in order to learn, by this method, whether this star was in the elementary region or truly existed among the celestial orbs — and what its distance from the Earth itself was — I investigated whether it had any parallax, and how great, in the following way. I observed the interval between this star and Schedir of Cassiopeia [Schedar] (chosen because this star occupies the meridian at almost the same time as the new one) both when the new star was near the zenith and when it was farthest from the zenith, near the horizon. (Since the new star is removed by six degrees from the very zenith of that place [recte: from the zenith], it would induce no parallax there — and therefore no nearness of the Earth would have any effect on it in that place; rather its apparent position and its true position are joined into one and the same point, because the lines from the centre and from the surface of the Earth nearly coincide.) And in both cases — both when nearest the zenith and when farthest from it, near the horizon — I found exactly the same distance from the said fixed star, not varied by a single minute, namely 7 degrees and 55 minutes. The same result I have established by repeated observation made on other stars: from which I conclude that the new star has no parallactic difference of aspect, even when near the horizon. For otherwise it would, at its least altitude, have been farther removed from the aforesaid star in the breast of Cassiopeia than at its greatest altitude.

Therefore this star must necessarily be placed not in the elementary region below the Moon, but far above, in an orb with respect to which the Earth does not have a perceptible magnitude. For if it were in the highest region of the air, below the hollow of the lunar sphere, it would have manifested, by the variation of its altitude, a change of position in its circle of altitude, near the place it occupied close to the zenith.

To set out a more reliable demonstration, let there be described a circle representing the meridian — the chief vertical circle of the outermost heaven, in which the positions of all the stars are considered — and let it be CBDE, whose centre is A. Let the diameter BE designate the vertical line, and CD the horizon. About the same centre let there further be described the circle MKL, which denotes the circumference of the Earth's globe. Between these, let another circle GHFI be drawn, which represents the lowest orb adjacent to the sphere of the Moon and the Earth, and let us imagine this star to exist in this circle. Let it first be near the point G, at its greatest altitude. It is plain that, in this position, it would be free of every difference of aspect. For both lines — the one drawn from the centre of the Earth and the one drawn from an eye set on its surface — would fall on one and the same point of the first-mobile circle CBDE, namely at point B, or near it, if the star is not exactly at G. (For these 6 degrees by which it is removed from the very zenith, when it is at its greatest altitude, would still induce no perceptible variation from that zenith.)

Now let this star be set in the same circle GHFI at its least altitude, namely at point O. It will then necessarily be seen in a different place of the outermost circle if the eye is set at K on the surface of the Earth, than if it were at A, the centre of that same circle. For if lines are drawn from the surface K, and from the centre A, through O, the place of the star, to the outermost orb EDEC, the line

Diagram. A concentric circle figure illustrating the parallax demonstration. An outermost circle is drawn with cardinal points marked B (top, vertical/zenith point), E (bottom), and the horizon diameter running left to right through C and D (C at left, D at right). Within it a middle circle bears the labels G (upper left), H (right), F (bottom), I (left) — this is the circle GHFI representing the lowest orb near the Moon and Earth. An innermost small circle near the centre represents the Earth's globe, with K above the centre, A at the centre, L below the centre, and M at the bottom of the small circle. From point K, lines are drawn outward through an intermediate point (the star's place, O) to the outer circle at P and Q in the upper right, where the parallactic separation P–Q is shown. The labels δ (the

star's place region) and the intersecting lines illustrate the offset between the line from the centre A and the line from the surface K.

- B (top of outer circle): vertical/zenith point
- E (bottom of outer circle): lower vertical point
- C (left end of horizon diameter): horizon point [marked $\mathfrak{J}$ -form at left]
- D (right end of horizon diameter): horizon point
- G (upper area of middle circle): point on circle GHFI
- H (right of middle circle): point on circle GHFI
- F (bottom of middle circle): point on circle GHFI
- I (left of middle circle): point on circle GHFI
- A (centre): centre of the Earth and of the world
- K (just above centre): point on the Earth's surface (observer's position)
- L (just below centre): point on the Earth's globe circle
- M (bottom of inner circle): point on the Earth's globe circle MKL
- P (upper right, outer circle): outer-orb intersection of the line from the surface
- Q (upper right, inner of P): outer-orb intersection of the line from the centre
- δ (between centre and middle circle, upper right): the star's place, O, region

drawn from A through O will reach P, while the one from K through the same O will reach Q. Therefore PQ is the arc of the first mobile showing the difference of aspect of the star.

I should like, however, to investigate the magnitude of the arc PQ, so that it may be known how great a difference of aspect this star, near the horizon, would have if it were placed in the circle IGHF just below the orb of the Moon, at the point O. And so that this may be done more conveniently, let the line QOK be produced until another line, issuing from the centre A, falls perpendicularly upon it, and let this be at point R. Now since the angle BKQ is known by observation — for it is the complement of the least altitude of this star, namely about 52 parts, and no great precision is needed here — its vertical opposite RKA will not be unknown either, being equal to it. There is, moreover, the angle KRA, right by construction; and the side KA is known by any measure whatever, for it is the semidiameter of the Earth itself. Then AR will not be hidden, by the 29th proposition of Regiomontanus on plane triangles.

So, if the semidiameter of the Earth KA is set at 100000 parts, as the whole sine, then — since the side KA is opposite the right angle at R — the side AR comes out at 88363 parts. Now at last I conceive a triangle ROA, whose two sides RA and AO are known. For AO, the distance from the centre of the Earth to the lowest surface of the orb of the Moon — which together with Copernicus we set at 1,200,000 parts of the kind in which the semidiameter of the Earth AK was 100,000 (I like to carry out this business in larger numbers, so that the calculation may be more convenient and more exact) — and since in the said triangle the angle ORA is right by hypothesis, the angle ROA will not be hidden, by the 27th proposition of Regiomontanus on plane triangles.

For when the side AR is multiplied by the whole sine, 88363×100000 is produced; and that number, divided by the side AO, leaves 1699 parts, namely the sine of the angle ROA, whose arc is 0 parts and $58\frac{1}{2}$ minutes — and this number determines the magnitude of the angle sought. To this angle ROA the angle POQ is equal, for it is its vertical opposite, as is clear from the Elements of geometry; and therefore the arc PQ, which measures this angle (since, on account of the immense distance between the sphere of the Moon and the first mobile, the arc PQ does not perceptibly differ from the arc of the circle intercepted within the same lines by the interval OP), and which designates the parallax of the star, will be $58\frac{1}{2}$ minutes — which was the thing sought.

So great, then, would have been the difference of aspect of this star, set at O, between that place which it nearly occupied near the zenith and that near the horizon, if it had shone in the nearest concavity of the orb of the Moon. But by many diligent observations (as I said above), made with an exact and by no means deceptive instrument, we find this to be false. Hence I conclude that this newly seen star is not in the circle IGHF, that is, in the highest region of the elements just below the orb of the Moon, nor in any place still nearer the Earth. For then it would have induced a greater magnitude of the arc PQ, and the difference of aspect would have been greater; but far above

the lunar sphere it holds its place in the heaven itself, and that in some orb so far removed from the Earth that the line KA, the semidiameter of the Earth, has no perceptible magnitude with respect to it. Rather, when the whole Earth is compared to that orb, it is found to count for nothing more than the place of a point. And this, in the eighth sphere — or not far from it, in the orbs of the three superior planets, which are higher — has been established by practitioners of the art. Hence this star is to be placed in the heaven itself, either in the eighth orb together with the rest of the fixed stars, or in the spheres lying nearest beneath it.

That it is not, however, in the orb of Saturn, nor of Jupiter, nor of Mars, nor of the other planets, is plain from this: that although several months elapsed, it did not move from that place by a single minute with a proper motion of its own — which would have had to happen if it were in some orb of the planets. For it would be moved by the proper motion of that orb, contrary to the rationale of the first mobile, unless it were at rest in one of the poles of the orb — from which, however, it is removed by 36 degrees. For all the orbs, revolving on their proper poles, carry round the heavenly bodies with them, or are carried round by them (as Pliny [Pliny] and certain others are pleased to hold). Unless someone should wish to deny the opinion received among philosophers and mathematicians, and to assert that the stars revolve in immovable orbs (which is absurd). Hence, if this star were established in any of the orbs of the seven wandering bodies, it would necessarily be carried round together with that very orb to which it was affixed, against the daily revolution. And this motion would also have been observed, even by an attentive eye without any instrument, over so great an interval of time, in the very slow progress of Saturn's sphere.

Therefore this new star is neither in the elementary region below the Moon, nor in the orbs of the seven wandering bodies, but has its place in the eighth sphere among the rest of the fixed stars. Which was to be demonstrated.

From this it follows that it is not any peculiar kind of comet, nor some other kind of fiery meteor that appears here and there. For all these are generated not in the heaven itself but below the Moon, existing in the upper region of the air, as all philosophers testify — unless one were willing, with Albumasar [Albumasar], to maintain that comets are born not in the air but in the heaven. He thinks he once observed a comet above the Moon, in the sphere of Venus; but whether this can be so is not yet established for us. With God's leave, if in our age some comet should appear, we will inquire into the certainty of the matter. And even if we grant this to be true (which I scarcely admit, along with the philosophers), it still does not follow that this star is a kind of comet — both because of its very form, which it has in common with the true stars, and because it was unlike the shape of all the comets seen up to now; and because it moved by no proper motion, over so great a time, either in latitude or in longitude, as has been observed to happen with comets. For although these sometimes seem to rest in one place for a few days, yet they do not do so for so long, nor so exactly, when diligent observation is made through an exact instrument; they do not keep the same position.

I conclude, therefore, that this star is no kind of comet, nor any fiery meteor, whether generated below the Moon or above, but is a star shining in the

firmament itself — one never beheld at any age from the beginning of the world before our own times. And this, I judge, has been sufficiently stated and demonstrated concerning the star's situation, both with respect to the zodiac and with respect to the diameter of the world and the orbs of the heaven. Now let me proceed to the rest.

ON ITS MAGNITUDE, LIGHT, AND COLOR

Artificers consider the magnitude of stars in two ways: first, with regard to their visible and apparent diameter; second, with regard to the true magnitude they actually possess in the heavens. For although the stars appear quite small to us, and seem to shine in the sky no differently than tiny torches, nevertheless the ingenious observations of the mathematicians have established that they are not merely equal to the entire terrestrial globe, but far surpass it in their own magnitude. Indeed, scarcely any star can be seen in the firmament that does not exceed the earthly mass at least ten times over at the very minimum — to say nothing of those of the first rank, which surpass the earth's magnitude a hundred and five times. Although this may seem incredible to many, no doubt at all will trouble anyone who considers their immense distance from us.

Therefore, even though this New Star appears small to the sight, it nonetheless truly possesses an enormous magnitude. It has not, however, always appeared of the same size. For at the outset, in the month of November, when it first began to be seen, it surpassed in visible magnitude not only all the fixed stars but even the planets themselves — and indeed it exceeded Jupiter [Iovem], then nearest the earth, and Venus, that brilliant star, in apparent size. Afterward it gradually began to diminish, so that by the month of December it was nearly equal to Jupiter; in January it was a little less; and in February and March it appeared equal to the fixed stars of the first rank, and was reckoned among them. At length it diminished still further, so that at the present time, namely at the beginning of May, it does not exceed the stars of the second magnitude. And just as it has decreased in this way with respect to its visible diameter, so too it is reasonable to conclude that its true magnitude has likewise varied.

Now at the beginning, when it far exceeded the stars of the first magnitude, it surpassed the entire mass of the earth by an incredible amount. For if the fixed stars of the first rank exceed the earth (according to the mathematicians) a hundred and five times over, and this New Star — as far as it was removed from the earth at the same distance as they are (as we demonstrated above) — held a far greater visible diameter, then it necessarily also exceeded by far more than a hundred and five times the combined mass of earth and seas, at the outset. But as

time went on and it diminished, it can no longer be larger than the earth itself, being now the size of stars of the second rank.

As for its light, it is seen to be brighter and more radiant than all the rest, so much so that at the beginning it could sometimes even be discerned in broad daylight near midday, when no density of air dimmed the sky. It also twinkles like the other fixed stars, and very much so. From this too it is evident that it is not to be placed among the orbs of the planets, but in the eighth sphere together with the rest of the fixed stars (as we asserted above as well). For the planets do not twinkle, but only the fixed stars — some of them more, others less — whether because their very great distance from us produces this effect through the intervening air, as some suppose (which I do not believe, for otherwise Saturn at its apogee, when it is nearest the fixed stars, would also twinkle), or whether because the fixed stars revolve perpetually upon their own centers, and from this, according to the quality of the air, send forth a twinkling to the eye. The latter view, with the Platonists, I hold to be the more correct.

As for the color of this star: it did not always retain the same hue. At the beginning it appeared whitish, and came close to the splendor of Jupiter [Iovial]; but as time went on, with its light contracted and condensed, it degenerated into a reddish, Mars-like glow — such as is the color of Aldebaran [Aldeborae], or of the star that reddens on the right shoulder of Orion. Yet it was not always so red as this one on the shoulder, but came closer to the color of Aldebaran. Now, however,

having put off that Mars-like redness, it has passed into a livid whiteness, so that in this month of May it presents itself as somewhat resembling Saturn and Venus.

That this star has so perceptibly changed in magnitude as well as in color (as we have already said) is sufficient proof that it is not located in the Elementary Region, below the orb of the Moon, and that it is not some peculiar kind of comet or some other fiery exhalation of whatever sort. For if it was possible for some new Body to be generated in the Aether itself — which we proved above concerning this star, by infallible Demonstrations, against the opinions and decrees of all the Philosophers — then it will be judged far less impossible and absurd that this same New Star should admit some alteration of magnitude and color. Indeed, just as it came into being at some time in the heavens, beyond the common Laws of Nature, so too, if it should cease to exist in that same place (as is credible), contrary to those same Laws of Nature, I do not see what could follow from this that is any more absurd than the former.

The rest, which concerned Astrological Prediction, I willingly leave aside.

These were the things I commented at that time concerning that unusual and admirable Star. Although, as regards the more general and principal points, they are reasonably sound when called into question, and do not greatly diverge from what we have now at last set down more fully and more perfectly concerning the same star in the Second Part of this Book, nevertheless they contain certain particulars — these too of no great moment — which have not been examined with complete exactitude. Whatever, therefore, in those earlier writings deserves some special correction, I will now discuss.

As for what I asserted in the First Part of this writing — that the course of all comets is irregular, unstable, and wandering — this came about rather because I followed the commonly received opinion concerning comets, than because any certain experience had made it known to me. For up to that age of mine I had observed no comet at all.

It may perhaps be the case that the motions of comets are not so constant, nor so reducible to rule, as those of the planets that are coeval with the World; yet they are not driven in a tumultuous and disorderly fashion, as I then supposed. For they do not leap about in a wandering way from fast to slow, or from this direction to that, but in succession and by a fitting and continuous progression they change their speed of motion into a slower one, or the reverse — just as we see also in the planets. And for the most part they describe a very great Circle in the heavens, not wandering wildly here and there, as several comets, carefully observed by me afterward, have taught me plainly enough; so much so that I have come to recognize it as not entirely impossible to establish a fixed Hypothesis that would account for the apparent inequality of their motions — as these and similar matters will be made clear in the following Books.

As for that New Star of Hipparchus, although I there hesitated as to whether it had vanished again, or not, and left this undecided, the matter holds little difficulty. For if it once arose miraculously, then it is reasonable that afterward it did not remain undissolved

for very long, but was dissolved and disappeared — just as this star of our own age has been seen to do, which is consistent with the fact that it is sufficiently clear from this that it did have some motion, since Pliny [Plinius] says that this Star had a certain motion. Now indeed, in that whole vast Theater of the heavens, no stars are found endowed with any perceptible proper motion, apart from the

seven Planets, which have occupied the heavens from the foundation of the World; and Hipparchus [Hipparchus], that supreme investigator of the heavens, knew well enough that this was not one of them. A little later, then, that very Star seen by Hipparchus vanished — which the Plinian words too do not obscurely suggest, when he says that Hipparchus measured all the rest of the heavenly bodies with his instruments, in order to know whether they were being born, or at some time would perish; both of which questions he no doubt saw answered in this Star.

The rest of the matters contained in the earlier part need little revision, and are sufficiently consistent with those that are treated in this Book.

In the Second Part, where I noted the distances of the three stars of Cassiopeia [Cassiopeae] from this New Star, I employed them then a little differently than they have been determined in Chapter Four [Capite Quarto], where they were limited by us with a more accurate balance — chiefly for this reason: that at that time the pupil of my eye, from the place on the Instrument where it was applied, was rather off-center, so that I had a less accurate view; and because, through the slits of the earlier sighting-vanes [Pinnacidiis] on either side, the Parallels — as I afterward discovered — did not allow me to establish the collimation properly; as I have also explained in the cited Chapter, and as I now restore, set right, and amend by means of the more recent Instruments. The discrepancy, however, that occurred was not so great — namely at least $4\frac{1}{2}'$ in the case of Schedir of Cassiopeia [Schedir Cassiopeae], at least $2'$ in the case of Lucida Cathedrae, and at least $1'$ in the case of the Flexura near Ilia — quantities which are not greatly regarded by the knowledgeable. Now I derived the place of the Star from these distances — namely those of Lucida Cathedrae and of the Flexura — Geometrically, by means of Triangles, in a manner not unlike that by which we proceeded in Chapter Five [Cap. Quinto]; where it is to be noted that when I found the Arc AB representing the distance between the fixed stars to be $2^{\circ}6'14''$ at that time, and said it agreed with the observed value, this did not correspond exactly, down to the very last scruple, with the repeated distances of the stars in the Asterism of Cassiopeia [Asterismo Cassiopeae]. Yet the difference is no greater than $1\frac{1}{2}'$, and this — on account of the Eccentricity of the eye (of which I have spoken) — could not then be perceived, since it was in itself not at all large.

Indeed, in the whole course of the Operation I had not everywhere applied so scrupulous a diligence; whence it came about that the Sides and Angles sometimes turned out a little differently than they were there assigned — some of them also corrupted by a fault of the Typographer — all of which, however, we

have restored to soundness by prefixing a repetition of the writing. Nor indeed did a difference of any great moment occur. For the place of the New Star came out there nearly the same as here — namely at 7° of Taurus [γ], $18'$ in longitude, and at $53^{\circ}56'$ of latitude — which indeed differs from this place, once the revision has been applied, by scarcely $2'$ as to Longitude, and only $3'$ as to Latitude. Therefore this little digression does not deserve any great censure.

I had at that time worked out the calculation only once, since I was distracted by very many other occupations amid the demands of court life; and since, with a Globe of moderate size, I had found by Mechanical means that the place of the New Star squared sufficiently precisely with the end of 7° of Taurus [γ], at Northern Latitude 54° , I did not think it worth the trouble to recall the practice of Calculation to the anvil.

But as for the fact that the place of the New Star, thus found and revised, does not agree exactly with the one which we derived in Chapter Six [Capite Sexto] from these same stars of Cassiopeia by a similar process — this could not happen on the grounds that the distances were there assumed a little differently (although this too could induce some small amount of variation), but rather because at first I employed at least the places of the Fixed Stars from the Copernican numbers [Copernicanis numeris], without consulting the heavens. Here too it is to be noted that I deliberately rendered the Precession of the equinox for that Year greater by a single minute than the Prutenic Tables [Prutenicae Tabulae], derived from Copernican sources, report it. For knowing that those Tables by no means present this with sufficient scrupulosity, I preferred — by adding that single scruple — to complete the individual sextants of degrees in the Longitudes, just as also their Latitudes, not within the precision of a sixth part of a degree, as is indicated in the canons; and I wished to point this out here in passing, lest anyone suppose that the minute had been omitted there through some error.

I also knew well enough at that time that the places of the Fixed Stars greatly needed correction, and that they are expressed by no Tables in harmony with the heavens themselves. And so I promised that I would at some time, with the favor of Divine grace, restore them in corrected form for the benefit of the renewal of Astronomy, and communicate them for the public good — which I trust I have faithfully enough performed, at least in the Second Chapter of this Book, and which I hope I have so redeemed, with the pledge given on this point, that the cultivators of Astronomy will have nothing on this score to complain of, or to find wanting in these matters. In the complete Work of Astronomy, with the supreme Founder of the stars breathing favor upon our endeavors, I shall labor to supply

the rest of those things that have been omitted there — as many as can be observed in our region and discerned by any view throughout the whole Heaven.

Nor, however, did the place of the Star, deduced from the Copernican ordering of the Fixed Stars — that is, from Ptolemy or rather Hipparchus, by the mere application of the precession of the equinox — come out at all enormously wide of the truth: it was in excess in Longitude by only 5', and in Latitude by 14', which easily merits excuse for itself in that place. So too in the Declination and Right Ascension of the Star, to be composed from the Longitude and Latitude, a few small scruples were previously neglected. For in establishing the Declination there was wanting one minute; whereas as to the Right Ascension, about five were in excess; and in its culmination, three, which however we have now corrected by re-examination. But as for the fact that I then put forward that I had found the Declination of the same quantity by means of the Instrument — this is not quite aptly stated, but came about through a certain error, namely by assuming the distance of the Star from the Pole-star to be a few minutes less than it should be, on account of the apparent

the parallax, of which I have warned elsewhere, which insinuates itself more in such a great interval than in smaller ones and disturbs the precision of the sighting [collimatio]. At that time I preferred to establish the declination from the distance to the Pole star [Polaris], rather than from the least altitude of the star with the elevation of the pole applied, because I trusted the instrument more in the procedure by which I investigated distances than when, set up at the equilibrium of the horizon, I examined altitudes with its aid — for then it sometimes wavered on account of the instability of its support. Yet to confine and verify that wandering by applying further considerations would not have been very difficult, just as I afterwards did with many collated observations. From this I found the declination of the star to have been 61 deg. 47 min., closely enough — falling short by very nearly a quarter of a degree of the value we derived above from the distance to Polaris. There was also another reason that impelled me to rely rather on the declination derived from the distance of Polaris from the star: namely, that it agreed so exactly, down to the very minute, with the value that was reckoned by calculation from the longitude and latitude of the star once these had been found. But since the positions of the fixed stars on which all this depended were not firm and secure enough in the books of my predecessors, there was no need to attribute so much weight to this agreement. For the rest, I find nothing in these matters that especially requires admonition and correction.

In the third distinction, where I treat of the position with respect to the diameter of the world and the distance from the Earth, although I have left it well enough demonstrated that this star wholly excluded parallax and was by no means below the Moon but stood in the very highest firmament, nevertheless this very point was not established there clearly and completely enough. For as to the parallax in a lower position, such as the star would have had near the concave surface of the Moon, I introduced it competently enough, so as to prove from it how much more this star ought to have stood off from Schedir [Schedar] in Cassiopeia near the horizon than near the zenith itself. But as to my having neglected its parallax at the highest altitude, that was not done quite to the purpose. For there too it was not absolutely nil but reached nearly seven minutes, and the New Star would have approached Schedir [Schedar] more closely by just as much; and so this would have increased the difference of distances at the highest and lowest positions by the same number of minutes, and for that reason would also have rendered it more evident. But at that time I was unwilling to scrutinize everything with full minuteness, content to have shown that the star in no way had its place below the lunar sphere. Likewise I passed over a certain small discrepancy that was introduced by the difference in right ascension [ascensio] between the New Star and Cassiopeia, since they were not exactly together on the meridian at the same moment; I judged it enough to have indicated to intelligent readers the things that were most necessary, who would themselves easily discern each of the smaller points.

But the fact that I assumed the distance from Schedir [Schedar] to be 7 deg. 7 min. 55 sec. [Margin: 7. 7. 55] in both positions — which I have now corrected and made smaller by $4\frac{1}{2}$ minutes — in no way overturns what we were aiming at there. For with the angle of the instrument remaining wholly unmoved

both at morning and at evening, I found this very same interval exactly, that is, with the instrument's parallax subtracted. But since the center of vision lay a little farther from the center of the instrument [Organum] than I then supposed, a somewhat larger diversity should have been deducted; and so the distance would have agreed more correctly with the one we afterwards corrected. Yet it made no difference, in whatever way that angle was reckoned — indeed, even if it had been left wholly unconsidered as to how great it might be — provided only that it was found to be exactly the same above and below (which we have several times confirmed): that sufficed for the soundness of our inference, by which we asserted that this star had the same distance in both positions, and on that account no parallax at all. For whatever the instrument's diversity may be, since the center of vision is not united with the center of the divisions, it would have to

be subtracted at the highest altitude and likewise the same amount at the lowest. And so as regards the measurement of the angle the matter would come out the same.

Furthermore, when I conclude — from the fact that this star was by no means below the orb of the Moon — that it must necessarily be raised into the eighth sphere [octava Sphaera], on the ground that it remained perpetually motionless: although this was not improperly stated in itself, yet the reality of the orbs, which I there admitted, compelled rather by the authority of the ancients than by the truth of the matter, I now by no means approve. For it is by now quite settled with me that there are no solid orbs in the heaven, whether these stars [Astra] or those carry them around — as I shall make manifest around the end of the whole work. Therefore it does not follow on this account that the star must necessarily have found its place in the tracts of the upper planets, on the ground that, fixed to them, it would have accompanied the revolution of the orbs, since there are in reality no such things there. But the same could be inferred by other proofs [Tecmiriis] — namely, that this star existed in the space of no planet whatever, but altogether among the fixed stars themselves, just as I sufficiently established in Chapter Six. So too, when I asserted that comets are not generated in the heaven itself but wander in the upper region of the air — adhering too credulously to the common opinion of the philosophers — that is by no means how the matter stands. For afterwards, taught by my own experience, I came to know well enough that they are produced in the heaven itself and by no means below the Moon. Nor even then did I yet trust the authority of the Peripatetics so far as not to promise myself that, if any comets should appear in my lifetime, I would make trial whether the matter stood so or not; led into hesitation by this, that Cardanus [Gerolamo Cardano] reports in his *Centiloquium* that a certain Albumasar [Abū Ma'shar] observed a comet above Venus — though I have nowhere yet read this in the author himself.

And so, although on these two points I assumed the reality of the celestial orbs according to the opinion long since received, and conceded that comets are a fiery meteor in the air below the Moon, yet I have now treated both more correctly, instructed by my own observations, and have judged otherwise concerning them; from which it is quite clear that I did this not from any zeal for novelty, nor because I desire to fashion paradoxes in philosophy that rest on no foundations. For indeed I too, from the very beginning, was for a long time of the same

opinion as the Peripatetics, since their cause is defended by them with some plausibility. But certain conjectures of no slight weight, on which they chiefly rely for their part, drove me to abandon it — observations made from on high with subtle instruments and liable to no fault, and the same explored by geometrical rule [amussis] — and drove me to think otherwise at last, and to decide more correctly; as the following books will amply testify regarding these later conclusions of ours about comets, which rest on a foundation by no means slippery and fragile. In those books I am confident I have also accomplished what I promised, namely, that if any of them should come forth in our age, I would establish a settled inquiry concerning their elementary or celestial position — and that I have done this abundantly enough, so that in this part too I may have redeemed the pledge given no less than in the restitution of the fixed stars. And I shall not be reluctant to achieve the same yet further hereafter, if more comets should shine forth while I am still alive, for the sake of more fully confirming the truth.

The things I set forth in the fourth part, concerning the true magnitude of the star and its light and color, are correct, and conform to those that I have brought forward on the same topics in this book — except that they do not distribute the particulars singly with sufficient subtlety and detail, but comprehend them briefly in a single general indication. Likewise the decrease of the star down to its final disappearance is not there indicated continuously, because the star itself had not yet completed half of its duration when those things were printed, as is also plain from the fact that I had assigned to it no term of its duration.

These are about all the matters I had to look into concerning that little commentary of ours, now revised and more critically examined — about which, however, no one has yet admonished me of anything, but I profess it of my own accord, as the truth requires, and as a fuller experience has taught me. And from this very thing others will be able to perceive clearly enough that it is from no zeal to carp at and disparage the opinions of others, out of some arrogant feeling or self-love, that I take notice of their writings, since I do not spare even my own lapses — detected or objected to by no one (which I might surely have passed over in silence) — but bring them too into the open and correct them.

I had afterwards appended a certain brief astrological judgment about the effects of this star, drawn conjecturally from the divinatory part of astronomy. To add this here, or to inquire into any such matter, I have been unwilling — just as I do not interpose my own opinion concerning the astrological predictions of others about this star, but leave these everywhere untouched. In the epilogue of this

book, perhaps, I shall touch in passing on certain matters concerning the portents of this star, and in some general notification I shall open my view about them — a view, however, plainly conjectural [stochasticam] (for it is not granted, as in the rest — concerning the place, position, magnitude, and the remaining appearances of the star, established by observation — to demonstrate this geometrically). Meanwhile we shall set about weighing what others, who have fastened the star to the orbs of the planets, have written about this matter.

CHAPTER NINE [CAPVT NONVM]

On the opinions of those who attributed some parallax to this star — yet not so great that it should thereby turn out to be sublunary, but such that it would be contained within the ethereal region of the second movables [Secundorum mobilium].

The things that, in what precedes, were pronounced by various authors about this unusual star, we have reviewed and examined, and they were thoroughly consonant with the truth itself as regards its position in the highest orb of the fixed stars. But those that we now intend to take into consideration do not aim so close to the appointed mark, but, deviating somewhat, make the star lower than is right and associate it less competently with the courses of the planets. This came about chiefly through a less circumspect observation and through the carelessness of those who administered the matter with insufficient subtlety. For it could easily happen that, in measuring its distance, they wandered by two or three minutes: and that tiny deflection at once attached some parallax to the star, and dragged it down — from the genuine position which it in fact held within the bounds of the fixed stars — to the lower seats of the planets.

Indeed, even the most illustrious prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel] — although he used instruments more skillfully fashioned than the rest, of solid metal, and conformed with perfect exactness as regards the division and the other requisites, and rightly disposed — yet that most distinguished and, of the literary republic, excellently deserving teacher, Dr. Caspar Peucer [Caspar Peucer], at that time the foremost professor of the University of Wittenberg, writing about this very star, attributed to it a parallax of three minutes, by employing, namely, a somewhat different elevation of the pole than the one he had obtained with the same instrument from the circumpolar stars. He himself nevertheless doubts whether the diversity of aspect could have been so great or not: so much so that he is unwilling to pronounce anything certain here, except that it was by no means greater — so that the

Wittenberg men, deceived by the falsity of the instrument, undeservedly extended it almost to a third part of a degree.

But in order that the opinion of this most illustrious prince, written out in full to Peucer, may become more fully known and be set before view, we shall add the letters themselves — in so far as they were written in German — translated into the Latin tongue, word for word; and when these have been a little looked into and weighed, we shall then subjoin Peucer's reply, and shall weigh that together with the Wittenbergers' observations and opinions about this star in a just balance.

A SPECIMEN OF THE LETTERS OF THE MOST ILLUSTRIOUS PRINCE WILHELM, LANDGRAVE OF HESSE, COUNT OF CATZENELNBOGEN, DIETZ, ZIEGENHAIN AND NIDDA, TO CASPAR PEUCER

Most learned and dearly trusted friend: Our beloved kinsman and brother, the Elector of Saxony, has informed us that within his domain a great, bright, and unusual star—or meteor—has been seen. We therefore turned our attention to this star here as well, observed it carefully, and found it at the 7th degree, 10th minute of Taurus, with a northern latitude of 53 degrees 40 minutes. Moreover, over the eight days since we first caught sight of it, we have not found it to have undergone any change in longitude or latitude. But whereas, in the judgment of all philosophers and astronomers, the bodies of comets ought to be translucent—which is also why they cast forth the rays of the Sun by interception—and whereas they are besides for the most part very swift in their motion: none of this appears in this star. On the contrary, over these eight days it has stood motionless and remarkably bright, so much so that scarcely any star in the heavens yields to it [in brilliance].

We therefore earnestly ask you to write back to us your own judgment by the present messenger: what you think of a star of this kind and how you assess it, and likewise how it has been observed where you are and by yourself, together with its attendant circumstances. We recall that Hieronymus Fracastorius [Girolamo Fracastoro] dreamed up the notion that there are certain stars which, when they sometimes approach the center of the world, become visible, but afterwards, on growing farther off, fade from view again by reason of their weakening light. He also attempts to construct the [solid] orbs and the theoretical models on these same lines, though without sufficient observation and demonstration. We have likewise read in Cornelius Agrippa, *On the Vanity of the*

Sciences, chapter 30, that—according to the opinion of certain mathematicians—there exist two further planets beyond the remaining seven, set diametrically opposite each other, which complete their course against the order of the signs in one hundred and forty-four years; these too, he says, sometimes become visible, and now and then wholly disappear from the same cause, when they rise higher [than usual].

We therefore graciously desire that you write back to us your judgment by the present courier, both concerning this star and also concerning the other proposed opinions; and likewise your astrological judgment as to what, for whom, and when this star may seem to portend. You will have done us a service taken in good part in this matter, and we shall acknowledge it with our gracious goodwill toward you. Given at Kassel, the 14th day of December, in the year 1572.

Addendum.

As regards that unusual star, we have observed it with our instruments with all the diligence that could be brought to bear, and we have determined the altitude of this comet—if indeed it is to be called a comet—at its greatest elevation on the meridian to be precisely 79 [degrees] 30 [minutes], and at its greatest depression below the meridian 23 [degrees] 3 [minutes]. Now the elevation of the pole of this city is 51 [degrees] 18 [minutes]. From this it follows that the parallax, or diversity of aspect, of this comet is not greater (if indeed it is even so great) than 3 minutes; that its distance from the surface of the Earth is $1061 \frac{5}{7}$ [recte: $61 \frac{25}{33}$?] semidiameters of the Earth; and that at the top it is placed no more than nine semidiameters of the Earth beneath the sphere of Venus, under the sphere of the Sun. From all of which it is established that this star arose not in the elemental region (where the physicists place comets) but in the aether itself and in the incorruptible region, not far beneath the sphere of the Sun. We cannot conclude it to be a comet, because of its great brightness and

because it is devoid of motion. For it has persisted thus far at one single point of the eighth sphere—namely at 6 [degrees] 58 [minutes] [?], with a northern latitude of 53 [degrees] 36 [minutes]—and so, being placed so lofty, outside the elemental region. Nor can we readily affirm that God has created some new star, since such a thing has not been heard of since the founding of the world. Furthermore, in our judgment it seems to be diminishing little by little in both its magnitude and its color, so that it appears probable it will have a short life. As far, then, as we are able to judge, it is reckoned by us to be a remarkable miracle of some kind, and indeed one out of that number which forewarn of the Last Day.

For just as the Lord God willed that the first coming of His Son, our Lord Christ, be announced beforehand by a star, and through magi, so we hope that for this reason also this [star] foretells the last coming of our Lord Christ. But however that may be, experience will teach whether something especially notable follows. We have also taken care to have our mathematicians diligently investigate, in all the descriptions of comets that have appeared since Christ, and they find none—except a single bright star of this kind, which they reckon shone in the year of salvation 389—and the irruption of the Goths and the destruction of Rome by Alaric followed upon it. Since this star portends irruptions of Scythian peoples (from which quarter Muscovy lies vertically [overhead]), and since therefore, according to the dictates of the astrologers, it chiefly directs its forces upon those lands, these matters do not seem to disagree with what is happening in the Polish election, and—as far as concerns the Turk—not to be at odds. May the Lord God in His mercy turn this aside and prevent it.

Wilhelm, Landgrave of Hesse.

These were the first letters of the most illustrious Prince the Landgrave, written about this star to the most renowned Peucer, with a part added from a letter of the same Prince to the most illustrious Duke of Saxony, Augustus—who at that time administered the Electorate of Saxony and Meissen, and who had first informed the Landgrave about this star. Let us therefore now examine more carefully the contents of these letters.

As to what the most illustrious Prince Wilhelm says: from the outset he calls this star a "meteor," admitting it as such, perhaps in imitation of the aforesaid Duke Augustus of Saxony. For afterwards he himself argues that it is not a comet, much less any sublunary meteor.

The place of the star, which he shortly afterward fixes at $7\frac{1}{2}$ [degrees] of Taurus and latitude $53\frac{2}{3}$ [degrees], he later corrects somewhat. In longitude it exceeds the exact position of the star here by very nearly a quarter of a degree; in latitude it falls short by only five minutes, as becomes clear when a comparison is made with our own findings.

He also rightly asserts that the star always stood motionless and remained in the same place.

As for what he records concerning Hieronymus Fracastorius [Girolamo Fracastoro]—that he held there to be certain stars which sometimes, on approaching the center of the world, are rendered visible, and then again, on

receding, disappear—these things are nothing else (as the Prince himself rightly declares and judges of them) than mere dreams

and idle tales. For who, in all the so many ages of the world that have passed, has ever noticed these stars ascending or descending—or by what motion, I ask, would this come about? A straight-line motion does not belong to the celestial bodies; and a circular motion would not permit these stars to lie hidden for so long, or to be seen only for a short while, whether the motion were slow or swift. One may therefore not unreasonably marvel that Fracastorius, a man otherwise outstandingly learned and endowed with a penetrating mind, dared to maintain such things—especially since he himself frames the heavens with homocentric orbs, in such a way that he does not doubt to assert that the planets too, throughout their ascents and descents, are made circular, neither nearer to us nor farther, against plain experience. Why, then, does he grant to invisible stars what he denies to the visible planets, committing himself to what is equally absurd in both cases? It will therefore be strange if Fracastorius supposed anything of the sort.

And yet, in going through his book *On the Homocentrics*, I have not so far noticed that passage—unless perhaps the illustrious Landgrave deduced it from the end of chapter 10, where Fracastorius asserts that there are certain orbs which our senses cannot reach, and that these either have their own stars not perceptible to us, or were made on account of those stars which other [orbs] do possess. He has indeed in that same treatise other things no less absurd; indeed, the whole is almost teeming with opinions that are inconsistent and impossible, and that contradict the very senses. From these, moreover, no one will adequately save the celestial appearances, nor reduce them to numbers. But on these matters it would be too long to discourse here. A more suitable place will perhaps be given elsewhere for vindicating a heaven that is utterly fluid and simple from so many fictitious and incongruous orbs—whether the Fracastorian or the homocentric ones.

Nor do the things deserve any greater credence which that most empty contriver of empty notions, Cornelius Agrippa, blurted out—whose words these are, the ones the illustrious Prince cites from chapter 30 of his book *On the Vanity of the Sciences*: "By the tradition of the Indians there are even now in the heavens two stars set diametrically opposite each other, which complete their course against the order of the signs in no fewer than 144 years. Alpetragius [al-Biṭrūjī] too judges that there are even now in the heavens various motions unknown to men; and if this is so, there can also be there stars and bodies to which those motions

belong, which men either cannot perceive on account of their excessive altitude, or which have hitherto been detected by no skill of observation."

These things, more empty than all emptiness, this man did not blush to fabricate with brazen brow as a mockery of astronomy, since nothing of the kind has ever been seen, whether by the Indians or by any men in any age.

For how could the Indians perceive anything in the heavens which would not also be plain to other peoples, the whole heaven turning round in 24 hours? Unless someone should wish to say that these stars are seen near the Antarctic pole, and that they lie hidden from the inhabitants of the northern tract of the Earth. That, indeed, one may say—but to prove it is

by no means [possible]. There are indeed certain fixed stars there, visible to us, which possess an evident magnitude; these the navigators who in some recent years have boldly attempted [voyages] toward the Antarctic pole, beyond the equator, have—not unsuccessfully carrying out their enterprise—brought to light. But that there are moving stars there, seen only by a universal whirling [of the heavens], no one at all has observed. Falsely, therefore, are these things fabricated by the Indians—or rather are falsely and deceitfully imputed to them by that author of vanity. And even if it were permissible to grant that such stars could, after the manner of Fracastorius or Cornelius Agrippa, sometimes come forth and again be hidden by some unexplored motion (which is nevertheless in itself utterly false)—nonetheless this new star is by no means to be likened to those fabricated bodies. For if, through their peculiar descents and ascents, such stars sometimes appeared and were again withdrawn from our view, it must necessarily come about gradually and not suddenly. For nothing natural sustains a sudden or violent motion for long, especially among the celestial bodies.

Now it might be the case that this new star (of which we are treating) was successively diminished, in such a way that the diminution came about through its elongation from the eye of the observer—by ascending along a straight line (as Cornelius, and also Gemma [Gemma Frisius], maintained); one could pretend that this is how it happened. Yet since such a motion does not belong to the celestial bodies, so that its assumption might in some fashion be plausible as regards the decrease and disappearance of this star—and since this phenomenon, at the very first from its rising, attained the greatest magnitude it ever had, and the same magnitude was diminishing little by little—it by no means descended along a straight line from the deepest aether. For in that case it would at the beginning have been small, and afterwards, by successively increasing, would have grown larger—not otherwise than it would have diminished from view by ascending.

For this reason, I say, it was not borne downward from a higher position. Rather, it stood perpetually in the same place where it had been formed, until it utterly vanished. And so it in no way descended, nor is it consistent that it had any ascent at all.

Those addenda seem to have been taken not [from the letter] to Peucer but rather from some letter written to the Duke and Elector of Saxony. For there [Wilhelm] assigns the star a somewhat different place than before, and reasons a little differently about its parallax. He gathers this difference [of aspect] to be 3 minutes, so that [the star] would have to be placed very nearly just below the concavity of the solar sphere. But while he applies a pole-altitude of 51 [degrees] 18 [minutes] to that place, he arrives at this tiny discrepancy, [departing] from the complete absence of parallax, which would rather have been appropriate. For although this higher pole-altitude fitted Kassel better than the one I used above, while considering those same Landgravian observations communicated to me—nonetheless, since it had been noted there that the Kassel latitude of 51 [degrees] 16 [minutes] for the circumpolar stars was found by the same instrument with which the new [star] was observed, and at that time, it is fitting

and so it was: the same elevation of the pole must be used for this star as well. For the question that arose was whether this region rotates about the pole in exactly the same way as the rest of the world that surrounds the pole as its contemporaries. And so, if any small error from observation crept into the new star, it would also have something in common with the others: since the same elevation of the pole comes out at both points, that small discrepancy in working it out would be absorbed, and would be the less noticed. But if a more correct elevation of the pole were applied to Kassel relative to the rest of the circumpolar stars, the same would also have had to be demonstrated in this new star, so that its altitude too would have been brought into line.

It is certain that the elevation of the pole approaches more closely to 18 full degrees than to 16. For both afterward I myself determined it precisely to be 19 minutes, using instruments fitted out, after the manner of my own, with transverse subdivisions and with the application of pinnacides [Pinnacidiorum], and so the three seconds in the earlier elevation of the pole — which I deliberately used — are lacking. Even these three minutes, in which his Lordship [Illustriss. Princeps] assigns the parallax, could easily slip in during observation, so that at the least altitude one or another might be wanting, or again at the greatest altitude — which was harder to observe — some slight deviation might be committed.

For that quadrant which the most illustrious Prince [Illustrissimus Princeps] then used was not very large, and the individual minutes were scarcely separated out on it — as I myself learned firsthand when, three years later during my travels, I met his illustrious Lordship abroad. From this, too, his practice then was to sight the stars through the apertures of a dioptra. And in this method, unless the aperture of the forward sight of the dioptra — which is farther from the eye — is on the larger side, it is scarcely possible to discern a given star to be observed; whereas when it does have this larger aperture, it covers several minutes in proportion to the size of the quadrant. And so, since one cannot tell during observation whether the star is being sighted at the center of the more distant aperture or not, a deviation of two or three seconds is easily committed.

For this reason his Lordship himself did not wish to affirm categorically that this star had differed in aspect by precisely those three minutes, but pronounced it only as a hypothesis, adding these words: *if indeed it is that much*. He concludes, however, by geometrical demonstrations from these three seconds of parallax, that the comet was distant from the Earth by about 1062 semidiameters. And so he places it in the highest part of the sphere of Venus [♀], just below that of the Sun.

Now if matters did stand this way — if the parallax of three minutes were to be assigned only to the lowest altitude, and at the highest there were none at all — then since the star was $10\frac{1}{2}$ degrees removed from the zenith when it was at its greatest altitude, and there it admitted some difference too, so that not all of the parallax redounded to the lower position, both parallaxes would therefore have had to be separated out. Taken together they were thought to amount to 3 minutes, and one had to see how much of this belonged to the higher and how much to the lower altitude. Afterward the remoteness of the star from the Earth had to be reasoned out from this. And on this very principle [reckoning], not the sphere of Venus alone, but even the whole sphere of the Sun...

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would be found to be higher; and this most easily from our table of solar parallaxes, which in chapter 1 we appended, faithfully calculated. For there, under the heading of the maximum remoteness of the Sun from the Earth, for the lower altitude $2' 41''$ are gathered; for the highest, $0' 31''$. When these are taken together, $3' 12''$ result. From this it is clear that the star which the remoteness of the Sun's apogee carries is still to be raised higher, if those $12''$ are to be entirely absorbed, so that the separate parallaxes may exactly compose $3'$. And so it [the Sun's orb] would surpass the upper limit of the solar orb by 80 terrestrial

semidiameters, so that its whole remoteness from the Earth would equal about 1260 semidiameters — which exceeds the Landgrave's [Landgrauianam] reckoning of 200 by almost so much. And so, into the sphere of Mars [σ], according to the commonly received distribution of the celestial orbs in imitation of Ptolemy [Ptolemaei], it would have ascended.

This discrepancy came about because he rendered the lower altitude, from this same parallax, by more than a whole solar sphere too high — since he assessed the composite difference not separately, as we have just done. In just the same way Peucer [Peucerus] too went astray in a closely similar undertaking, as we shall make plain when we come to discuss his letters.

Now he draws a most correct conclusion: that this star was not in the elementary region, where the natural philosophers [Physici] suppose comets to be generated — although they assert even this without any sound experience, as we have shown elsewhere. From comets, moreover, he rightly distinguishes this star, wherever indeed they are produced, on account of the immobility by which it stood perpetually in the same place of the heaven. He assigns its position a little differently than before, placing the longitude at $6^{\circ} 58'$ of Taurus [τ]. This comes nearer to our own observation, for now at least 4 minutes are wanting. In the latitude, which he places at $53^{\circ} 36'$, now a little more than before is lacking, namely 9 minutes. But since this was investigated by means of a certain bronze globe three feet in diameter, it could not arrive at exact precision in such mechanical handling. Even in the times themselves of the azimuths and altitudes taken — for that route of investigation was then proceeding all too slipperily — a slight margin of error was able to alter the star's place perceptibly, as may be seen from the very observations geometrically resolved by us into numbers at the beginning of the preceding chapter, which do not everywhere yield the same place for the star, nor are they wholly consistent with those that the Prince himself established.

That this star grew, and hastened toward its consummation, and that in this matter a miracle lay hidden, he rightly affirmed. But whether it was a herald of the second coming of Christ in glory — just as another, seen by the Magi, was the herald in the flesh of his first coming — I would not say. Piously and plausibly indeed are such things put forward; yet to establish anything certain in these matters, even with the Prince himself not proposing them assertively, is hardly granted.

That around the year 398 a similar star shone forth is scarcely proved with enough security from the historians. For they, being for the most part little versed

in mathematics, can scarcely distinguish stars from one another, and from comets without tails — such as sometimes...

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are observed (as also in the year 1585. His most illustrious Lordship [Ipsemet Illustriss. Princeps] himself observed one of this kind, no less than I did, as will be established more fully in its proper place, when we treat of this professedly) — they did not learn. The appearance of this star did indeed fall very near that time at which Claudian the poet [Claudianus Poëta], under the fourth consulship of Honorius [Honorij], reports that a certain unusual star was seen by day; yet for the reasons indicated above, nothing certain can be made out — though I should suppose that, were I to take up the matter, with the help of the literature of the consul Hainzel [Hainzelj], a conclusion could be reached. But be that as it may: it is possible that new phenomena, comparable to genuine stars themselves, may sometimes appear in the heaven — or this one alone has furnished sufficient testimony.

And so it may suffice to have called up, for consideration, the Landgrave's letters addressed to Peucer in this manner, together with the appended annex. But what Peucer himself wrote back in reply to these — once a copy of his answer has first been added — we shall presently examine.

A COPY OF THE LETTER OF THE MOST DISTINGUISHED MAN, MASTER CASPAR PEUCER, IN WHICH HE REPLIES TO THE FOREGOING LETTERS OF THE LANDGRAVE.

[APOGRAPHVM LITERARVM CLARISS. VIRI D. CASPARI PEVCERI, QVIBVS ANTECEDENTIBVS LANDGRAVIANIS RESPONDET.]

Most illustrious Prince, most gracious Lord: I have received from your Lordship's [Celsitud.] courier the letter in which two principal points were contained. One concerned the new and unusual star, which is seen in many and diverse climates under the same asterism of the eighth orb; the other concerned the nature of comets in general. To both I shall reply briefly, so far as the burden of my present occupations has allowed. Concerning the star itself, I have set out my opinion and our observations for the most illustrious Prince, the Elector of Saxony [Electorem Saxoniae], our most gracious Lord. Since I understood that a copy of those letters had been sent to your Lordship, I shall, summarily repeating the chief points, add what we have emended in our earlier findings by repeated observations and by applying a more exact calculation, and what we have found to be changed.

Never in any age has such a star been seen in this place of the eighth orb, under the asterism of Cassiopeia [Cassiopeae], of such an appearance, such splendor, such magnitude — there is plainly no doubt of it. In figure it resembles the stars; in brilliance, purity of light, and magnitude it has hitherto surpassed them all, both fixed and wandering [Errantes], except Venus [Venere]. It stood motionless in one place of the heaven, after the manner of the fixed stars, which it also expressed by its scintillation and the tremor of its light, whereas the planets do not scintillate. In position and motion, however — for we have detected it to have had no motion other than that of the world's revolution — it made no change, from the very beginning. But in body it began to grow thin, in light to lessen, and in its radiance to alter the color from the clear and gleaming hue with which it rivaled Venus and Jupiter [Iovem] — so that it had outshone the former, and was outshone by the latter. This color, then, it manifestly began of late to change into a flame-like redness, rivaling Mars [Martis] (to which it is now far more similar than to Jupiter), from then on up to the 14th of December. It was first seen by us on the 16th of November. Some write that it was noticed and observed eight days earlier, that is, on the 8th of November; but with the same appearance, and the same disposition toward the second, fourth, and twelfth stars of Cassiopeia [Cassiopeae], with which it forms a σχῆμα ῥομβοειδές [Greek: schēma rhomboeides, "a rhomboid figure"]. With astronomical instruments...

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we have found it to be distant from the zenith, when it came nearest, 10 degrees 4 minutes; when it withdrew farthest and let itself down toward the horizon, on the meridian itself $66^{\circ} 27'$. From our horizon, however, in the first position it stood at $79^{\circ} 56'$; in the other [position] it stood distant $23^{\circ} 33'$. Its place, observed when nearest the zenith, fell at $6^{\circ} 25'$ of Taurus [♉], with latitude $54^{\circ} 16'$. When it was nearest the horizon, its place fell precisely at 6° of Taurus [♉], with northerly latitude $54^{\circ} 3'$. We therefore find the declination near the zenith to be $61^{\circ} 58'$, and near the horizon $61^{\circ} 39'$; and the parallax $0^{\circ} 19'$ — though the difference was not exactly determined, if indeed any difference at all occurs between the true and the apparent place near the zenith. Its right ascension we measured at 359° in 56 minutes of time, so that it falls almost upon the equinoctial colure itself, above the first point of Aries [♈].

Thus far have we observed, intending to take pains that, when the instruments we are now constructing are completed, we may explore all these matters more accurately and exactly — unless the star should vanish in the meantime, since it has by now been much attenuated. And indeed it now once more seems, as it

were, to hold its ground, nor does it go on diminishing further. Unless we find a larger parallax than 19 minutes, its distance from the Earth will surpass 164 semidiameters of the Earth. Thus it will reach the sphere of Venus [♀], crossing the orbs of the Moon [☾] and Mercury [☿].

This so great a distance utterly disturbs our reasonings, so that we cannot yet establish whether it ought to be reckoned among elementary things or among the ethereal. In appearance, purity of light, brilliance, it fashions and represents the fixed stars by its immobility and scintillation; in magnitude and brilliance it represents the planets. But from both it is at once separated and set apart by a change in its constant magnitude, light, and color, of a kind that has hitherto been observed in no star. By itself, indeed, among the fixed stars it is to be reckoned by the number of the stars of Cassiopeia [Cassiopeae], and by its newness in that place of the eighth orb; while from its distance from the Earth, comprehended from the parallax — which does not yet surpass the sphere of Mercury — by [the fact that] it exceeds [that sphere]. From the planets, on the other hand, by its immobility, its position outside the zodiac, [and] by the number of the planets — since it is most certain that more than seven have never in any age been numbered by the masters of the art. For fictions and fables, or the wantonness and ingenuity of men at play, do not move me. To neither class, therefore, can it be assigned. Nor can we rashly affirm that new stars are created divinely in the ethereal region — since it is expressly written in Genesis [Genesi] that God rested on the seventh day; and ancient religion has affirmed this, [and] pronounced an angel to have shone forth, in the appearance of a star, before the Magi at the birth of Christ. If, kindled from elementary matter gathered on high and from the power of the ethereal light, perhaps by the rays of Jupiter [♃] or Venus [♀] or both, we were to assert it to have blazed up — the distance from the Earth fights against this, as do the scintillation and the parallax, which they show to be at its greatest. And if we were to maintain that beyond the lunar orb a mass of vapors drawn up from the Earth was carried aloft, the whole doctrine of the distinction of the ethereal region from the elementary would be overturned — which doctrine the experience of so many thousands of years has demonstrated to be neither vain nor false, since the ethereal region has undergone no changes, whereas the elementary is subject to perpetual and almost momentary ones.

These considerations draw my mind in opposite directions, so that I cannot, even now — before it has burned out — settle with myself in which class it is to be reckoned. Yet on account of the evident changes it undergoes, I incline rather to the view that it is contained within the elementary orb, that it has been kindled from elementary matter, and that, as it began, so it will cease to be.

Again, when I consider also the predictions of the Son of God, who prophesies that future things — that the powers of the heavens shall be moved, and that in heaven there shall blaze and shine forth the sign of the Son of God, and that there shall appear other signs and portents, σημεῖα καὶ φόβητρα [Greek: sēmeia kai phobētra, "signs and terrors"] — I plainly conclude with myself that this unusual star has come, with a force far other and far greater, than [that] from the elementary or the ethereal orb; and that it has been set divinely, not only that, with the last things proclaimed and the...

with great calamities and disasters, calling the elect back to repentance — but much more to portend that the final coming of the Son of God for the Last Judgment, and the glorious deliverance of the wretchedly afflicted Church, is now drawing near, indeed already at hand.

In short, that star chose to shine in a lofty and conspicuous position and with an unaccustomed brilliance, so that it might be seen and recognized far off by everyone, and might catch the eyes of all in every quarter.

Therefore, although I still hold back from asserting this, I do not exclude it from the class of comets: among these, Aristotle distinguishes some as bearded or tailed, others bristling and maned over their whole surface, those properly called κομηῖται [Greek: komētai, "comets" — long-haired stars], because they are comet-like and hairy, which is perhaps the kind this star is. But it could not be apprehended by the eyes as such, because of the magnitude of the distance. Pliny [Pliny the Elder] lists several more forms, among which the δίσκος [Greek: diskeos, "disc-shaped"] is similar to its own name; but this one is not entirely unlike the present figure. The same author records that some of them move in the manner of wandering stars, while others remain fixed and immobile. For that reason I am not moved by the star's immobility.

To rehearse the disputes and opinions of the ancients about comets themselves, on which they differ very widely among themselves, would take too long. Properly speaking, such things are not σώματα διαφανῆ [Greek: sōmata diaphanē, "transparent bodies"], which by their own nature and substance are δυνάμει διαφανῆ [Greek: dunamei diaphanē, "transparent in potency"]; rather they come to be by an energy, struck by the rays of the Sun and as it were suffused with a διακλάσει [Greek: diaklasei, "refraction"] or illumination of those rays, and with ἀνάκλασει [Greek: anaklasei, "reflection"] refraction. Nor is the tail, which in other cases is seen stretched out lengthwise, anything but a refraction or transmission of the Sun's shining rays. Nor are they ἐκφάσεις [Greek: ekphaseis,

"appearances"] or φάσματα [Greek: phasmata, "apparitions"], mere apparitions or things seen: nor are they kindled or set ablaze without an underlying material.

For even though there is in all things another, more divine power — which I do not deny — than can be propagated from the elements, nevertheless most celestial things, and above all meteors, are full of the divine majesty, full of wonder: their origin and nature we may marvel at more readily than we can explain their causes. Still, I embrace Aristotle's view above the others, and that comets are something οὐσιῶδες [Greek: ousiōdes, "substantial"] — for, to say more plainly what I think, I judge them to be ὑποκάύματα μετέωρα ["smouldering things aloft"] composed of inflamed elementary matter. To Fracastoro [Girolamo Fracastoro], a man of outstanding genius and judgment, I leave his fancies, which are ἀναιτιολόγητοι καὶ ἀνεπίδεικτοι [Greek: anaitiologētoi kai anepideiktoi, "without causal account and undemonstrated"]. As for Cornelius Agrippa [Heinrich Cornelius Agrippa]'s dreams, blasphemous against God and contrary to the reasoning and judgment of approved philosophers, I detest them. Nor do I rashly depart from the footsteps of the ancients except when convinced by clear arguments.

To pronounce in detail about the significations would be rash, since the outcome is not yet known. For I judge that this must by all means be awaited: namely, until the light, the magnitude, and the color begin to change, and whether it is also going to change its place; and if it acquires motion, toward which region of the world it will turn itself, which planet's lead it will follow, and how long it will remain shining. That it portends supreme and fatal changes for the human race is plainly beyond doubt. But the very course of present affairs and events in almost all the kingdoms and regions of the world threatens us with the same, so that Heaven and Earth seem to conspire together for the fatal punishments of the manifold sins of the whole human race. Therefore let those of us who are, and who profess ourselves to be, true members of the Church and sons of God, lift up our heads to Heaven — where, according to Paul [the Apostle Paul], our citizenship [πολίτευμα; Greek: politeuma, "commonwealth, citizenship"] is — and let us pray with ardent vows and groans that our Redeemer and Savior, the Son of God, may hasten his coming and snatch us from the vast storm of the most savage calamities, which from every side now seem to press upon our necks. Let each one of us also reflect on a true and earnest conversion to God, and consider that these heavenly portents concern each one of us, denouncing and threatening punishments upon each — most certainly upon us...

to convince us. But concerning the star itself, as far as I shall hereafter have investigated it, and what I shall have judged it to portend from the canons of the astrologers, I will write to you when everything has been more accurately examined and weighed. Farewell and prosper, most illustrious Sir. For you, as you enter upon the new year, I pray firm health, a tranquil and salutary government, fortunate counsels, and success in your undertakings. Given at Wittenberg, on the Kalends of January, in the year 1573.

In this way, then, did that most learned and excellent Peucer [Caspar Peucer] reply to the illustrious Prince Landgrave [Wilhelm IV of Hesse-Kassel], whose letter's contents let us now likewise examine.

He calls this phenomenon at the outset, rightly and aptly, a New and unaccustomed Star; and truly he asserts that nothing of this kind was ever seen in any age at that location, and that it was immobile after the manner of the fixed stars, revolved with the whole universe in the same motion, and twinkled in the manner of the Fixed Stars — all of which he rightly affirms.

Concerning the variation of magnitude, light, and color, moreover, he reports things not incongruous with our own observations; as also concerning its arrangement with respect to the Stars of Cassiopeia [Cassiopeia].

But when he comes to the observations — although he places them at the same altitudes that are recorded in the preceding chapter in his letter to Hieronymus Wolf [Hieronymus Wolf] — yet these very observations, whether because they were not correctly applied to the more proper elevation of the Pole, or because they have some latent flaw in themselves, or for both reasons, are not in every respect exact. For he seems to presuppose the Pole-altitude of that city to be $51^{\circ} 54'$ [the printed value reads "p. 51 / 54"]. This is the value that Reinhold [Erasmus Reinhold] — a man of laudable memory, and his Teacher who deserved excellently of him in these arts — assigned in the Prutenic Tables [*Tabulae Prutenicae*]. But whether this is correctly determined ought to have been explored beforehand. Indeed, granting this height of the Pole, the declination would come out such as he himself adduces, in its upper and lower position, and the Parallax would come out as $19'$ [Margin: 19 m] according to these data — which, however, was in reality nothing at all, as we have irrefutably demonstrated. But concerning this matter, and from what source such a deviation arose, I shall afterward inquire when I treat of the views of the Wittenbergers, the same matters that Peucer here builds upon; and I shall lay open the occasions of the aberrations as far as can be done.

The interval of each of the two altitudes agrees well enough with those that were discovered at Augsburg by the Consul Hainzel [Paul Hainzel] with our very large Quadrant; and if it be halved, it expresses the complement of the declination of the place of the New Star not incongruously — so that on that account some not inconsiderable flaw must necessarily have lain hidden in the perpendicular or the sights of the instrument by which these altitudes were taken; the rest of its frame and graduation being moderately well in order.

But Peucer here attributes to the star a Parallax of 19' [Margin: 19 m] quite improperly; and what he wrote earlier to Wolf about the imperceptibility [insensibility] of this parallax is much more correct...

they have more correctly. For there, having collated all the observations, he declares that no discrepancy appears between the apparent and the true place, and that therefore he has much more correctly determined that he detected no parallax at all. For in the very truth of the matter, this Star possessed no diversity of aspect that could fall under any of the senses. Therefore he labors in vain now in discerning a place seen as different from the true place near the vertex and near the Horizon, since in both cases it was entirely the same — as he is his own witness in the earlier passages. Although even in these very seen positions, as he calls them — in a place both more elevated and lower in situation — he by no means hit the mark, in that both here and there he attributed somewhat less than is just in longitude, and somewhat more than is just in latitude. For the upper Longitude falls short by nearly half a degree; the lower [is] 54'. The upper Latitude likewise exceeds by about half a degree; but below, it does not hold quite to a third part of it. Nor do I understand by what reasoning a seen place could be determined, if this Star admitted so perceptible a Parallax: for since its place [seen] from the surface of the visible earth would not remain altogether the same throughout its whole revolution. I have therefore referred these rather to the disposition near the Meridian on both sides, in which positions also such wanderings with respect to the Center and the surface of the earth would have been obtained in much the same way, had it been so near the earth that it would have been subject to a Parallax of 19' [Margin: 19 m]. But since this was plainly none at all, the rest is built up to no purpose. So too in right ascension, to be recorded at nearly half a degree, it holds rather less than is just.

There is also need of a warning concerning this work: namely, that one should impute the Parallax of longitude and latitude only to the lower situation, and not likewise to the upper, and that on this account the whole matter is not decided exactly enough. For the two Parallaxes of altitude ought to have been separated

and weighed apart — both near the vertex and near the Horizon, had any really been present in this Star — provided that its place, seen in either situation of the Meridian, were duly determined. Indeed, the distance of the Star from the Earth has not been properly disentangled from this composite Parallax. For inasmuch as he presupposes it altogether at 19' [Margin: 19 no n], it will at least be removed by 164 [Margin: 164] semidiameters of the Earth, so that it will obtain the boundary of the orbs of Mercury [☿] and Venus [♀] according to the Ptolemaic arrangement, but it will sink into the very Sphere of Venus [♀] by several parasangs, so that it will be distant from the earth at about 190 semidiameters — which in the nearest altitude yields a Parallax of 16' [Margin: 16 m]: but in the highest of the three, very nearly [the same]: so that thus both composite Parallaxes complete 19' [Margin: 19 m].

But as to why that excellent Peucer then committed so great a deviation in this Star, I judge it should be attributed rather to the wooden Quadrant — which Reinhold had once had constructed, and which, beyond doubt, had in the meantime undergone some alteration (if indeed it was ever free of every flaw) — rather than to his own want of diligence. It would therefore have been more advisable for him to have employed a more accurate exploration, such as he promises with newly built instruments, before he brought forward a judgment on a matter so weighty and unusual...

That the Star stood firm in its own quantity and would no longer undergo any further diminution — its earlier change — he then thought, because for a few days at least it so appeared to the sight; but afterward, when a longer interval had elapsed, it became sufficiently well known that it continuously decreased.

The distance from the Earth which he makes — 164 semidiameters — is indeed not very dissonant with the lowest disposition of the Sphere of Venus [♀] and the highest of Mercury [☿] according to the Ptolemaic distribution. For Mercury [☿], according to these hypotheses, is elongated higher from the earth by 166 [Margin: 166] semidiameters at most. Yet if the Parallaxes were duly discerned — and account were taken of that which occurred near the vertex — by the reckoning this Star would come to be raised a little higher, up into the Sphere of Venus [♀]. But since he was at that time too much attached to the Aristotelian traditions, and laid down beyond doubt that the Spheres of the Planets are real, how, I ask, could it come about that this Star should stand immobile within the orbs of Venus [♀] or Mercury [☿] for so long a time, carried around in the meantime by none of these? Yet he still doubts whether he ought to assign it to the ethereal world or rather to the elementary one — to such a degree that the Parallax (and that too

far too large for the sublunar regions to admit) drove him to it. So deeply does that ancient opinion, long imbued through the approval of the multitude, tend to strike root, that not even by experiences contrary to it can it be uprooted by any wedges.

What he adduces concerning the comparison of this Star with the Fixed Stars and the Planets squares well enough. And yet from these very things he could have gathered, even apart from the measurement of the Parallaxes, that a plainly celestial — not elementary — nature was infused into it. For the fact that it changed its magnitude, light, and color, contrary to the manner of the other Stars, sufficiently proves that it is not to be associated with their territories. For if it could come into existence there miraculously, suddenly and unexpectedly, beyond the accustomed laws of nature, then surely it was less absurd for it also to undergo these alterations in color and the diminution of its body, until it wholly vanished.

That new Stars should not be rashly affirmed to be created divinely in the ethereal region — he rightly indeed asserts. But if clear experience joins in proving this very thing, what then shall we say? Are the words of Moses [Moses], *And God rested on the seventh day*, to be understood so strictly, as though in a perpetual Sabbath he ceased from every operation? Or rather are they to be taken at least of those things which he determined to create from nothing at the beginning, and not of secondary works formed from preexisting matter? Whether, therefore, this work was mediate or immediate, it surely came forth by the decree and will of the universal Maker. So that on that account the words of Moses must rather be more correctly interpreted and excused than that an irrefragable experience itself be contradicted.

That the Star of the Magi was not a genuine star but rather a certain Angel going before them under the appearance of a Star — this I would not unwillingly grant, in keeping with pious antiquity. Nevertheless, that this Star is to be equated with that one, or that on its account new bodies can never at any time exist in Heaven, I would by no means hold to be a consequence. But concerning this...

that this star, which had appeared, was the more conspicuous one already sufficiently discussed earlier. And so Peucer [Caspar Peucer] remains in doubt and does not dare to assert anything definite about where this star should be placed. Nor is this surprising, since one steeped from his earliest years in Aristotelian teaching simply regards it as impossible that new bodies should arise in the heavens — even though the slowness of its parallax and the trembling of its scintillation point to the very opposite conclusion. For that reason he can only

with difficulty be torn away from the doctrine of the distinction between the aethereal and the elementary regions, a doctrine handed down by the Peripatetics, as it were from hand to hand, for so many ages now. And yet, if he had reckoned the mathematicians' observations of earlier comets sufficiently exact in every respect — observations not at his ready disposal and free of error — and if he had long since grasped clearly that these comets too were generated in the heavens themselves and overturned the Aristotelian principles, then in the case of this star there would have been all the less occasion for hesitation.

Overcome, then, by the authority of the ancients and by a long-approved opinion, he prefers — against his own experience — to attach this star to the elementary sphere, alleging changes in it which he himself concedes. But that this position is not necessarily proved we have already said, and have discussed the matter more fully earlier in chapter 3.

As for the predictions of the Son of God: although they do warn us about a sign of his coming that will appear in the heavens, still they do not openly indicate what sort of sign that future one will be. Nor does his prophecy proclaim that new stars will arise, but rather that old ones will perish — as I touched on regarding some of these matters in the chapter named above. Meanwhile, these and similar things may piously and thoughtfully be brought forward, so that a world too dissolute — or rather unclean, as far as the disordered morals of men are to be called — may be roused to repentance and to amendment, as if from a kind of long sleep in which it lies frozen.

Furthermore, that Peucer does not dare to remove this star from the class of comets is because he is too preoccupied and indulges an opinion drawn from the Aristotelian school. It is true that comets have sometimes been seen without tails, yet bristling shaggily on every side. But this star had nothing in common with those comets, and differed from them in many respects, as was indicated earlier.

The magnitude of the interval — even if this could to some degree contribute to the point, in that hairlike streamers, if it had had any, could not have been seen — yet some trace of them, over so long a time while the star lasted, and especially at the beginning when it was brighter, would have appeared to us, if only anything of that kind had belonged to it.

What he learnedly discusses about the diaphanous bodies of comets — whether by their nature and power, or by the rarity of the body, which he calls *diaclassis* [διάκλασις, "refraction"], existing through a certain *energeia* [ἐνέργεια, "operation"] from the illumination of an external light — I do not wish to repeat

here. Elsewhere I shall set forth what I think about these matters, by a resolution drawn from experience itself.

Furthermore, he declares — not beside the point — that in comets and in meteors themselves a great many things lie hidden, full of the divine power and worthy of wonder, things which it is allowed

to wonder at rather than to unravel. Yet he is reluctant to abandon the Aristotelian opinion on these matters, because it seemed to him more plausible. Although he rightly said what a comet essentially is, he pronounced a mistaken judgment about their location and generation — namely, that they are set in inflamed elementary matter. As will be shown beyond doubt in the following books, when we treat of these things expressly.

The follies of Fracastoro [Girolamo Fracastoro] and Cornelius Agrippa [Heinrich Cornelius Agrippa], which they brought forward from time to time about the stars, he rejects — not without justice — as irrational and indemonstrable; and we ourselves have earlier agreed with that censure.

Finally, he acts prudently in refraining from predictions and prophecies concerning the significance of this star. For even if the whole period of its appearance had already been established beforehand, those things were not so easily discerned by mortals as the star's form, position, distance, and magnitude were — which fell under the external senses and were measurable with suitable instruments. Indeed, even with the stars congenital to the world itself, as far as their significance and energy are concerned, a great deal still lies hidden — even in those matters that are thought to be sufficiently explained — much less in one issuing forth in the heavens miraculously and beyond all expectation. If we may surely recognize the effects and decrees of so sudden a light — for if the causes of its rise and procreation (as in the case of the others, which can be discerned more visibly) yet lay hidden from most people, since they were not duly observed, I will say nothing — to such a degree, then, who, I ask, will unravel the portents that lie far more deeply concealed and hidden from human investigation? Let it be enough to have noted these things in response to this letter of Peucer's; to which the most illustrious Prince, replying once more in the following manner, speaks at length, as we shall now add.

SECOND LETTER OF THE MOST ILLUSTRIOUS PRINCE WILHELM, LANDGRAVE OF HESSE, TO D. CASPAR PEUCER.

Most learned, beloved, and faithful friend: We have received your letter written on the 10th of January, and we kindly give thanks for your account of the new star that has appeared. As for your judgment, moved by the reasons you adduce, we plainly agree with you. For from the star's very first appearance we judged it to be something supernatural. By no means could we, from the most exact and diligent observations and considerations, have gathered it to be a Meteor or a Comet, nor that it was set in the elementary region. Since, therefore, it is established in the Aethereal region — where the natural philosophers leave no room for generation or corruption — it brings us all the more wonder. And so, as soon as we caught sight of it, and before we received your judgment about it, we wrote to our most dear kinsman and relative the Elector, that we reckoned this star to be one of the signs that will precede the Last Day of judgment.

As for your observations: they do not agree entirely with ours. We judge the cause of this to be that you are unprovided with suitable instruments. We, however, took care beforehand to have exact and especially well-wrought instruments made, namely

a double-cubit Quadrant, and another quadrant of one cubit, both made of brass, and revolving perpendicularly upon their proper azimuths; and we also had a most exquisite brass globe, divided with its due circles in brass with the utmost diligence, skillfully made. With these as intermediaries — however much, on account of the commonwealth and the administration of our government, we had for a while set aside the observations of the heavens — we diligently observed this star, especially at the beginning, for some while. For since God set such a portent before our eyes, we thought it would not be unbecoming to contemplate the same with dutiful attention. And, applying diligent observation, we observed the following.

The latitude of this place [the altitude of the pole of this place], as we observed it through the solstices and also through the highest, middle, and lowest part of the tail of the Great Bear [Ursa Major] (which around the feast of the Lord's Circumcision can be marked at the lowest and highest part of the meridian), we observed most diligently over several years to be P. 51. /18 [51° 18'], whose complement is the elevation of the equator, 38° 42'.

The altitude of this comet (if it is indeed to be called a comet) we found at the highest point above the horizon to be 79° 30'. With the elevation of the pole subtracted from the altitude given for the comet, there remains the arc of its

distance from the pole of the world, which is $28^{\circ} 12'$. Its complement is the declination of the comet itself, which it holds in that part of the meridian, namely $61^{\circ} 48'$. But since the comet, at ten and a half degrees, approaches our zenith, I cannot ascribe any parallax to it in that place — even if it had any — since it would be imperceptible. If, therefore, I subtract the comet's distance from the pole just found, namely $28^{\circ} 12'$, from the very altitude of the pole, there remains the altitude that the comet would have in the morning, when it is situated in the lower part of the meridian, namely P. 23. M. 6 [$23^{\circ} 6'$].

Yet through many and most diligent observations I have not found it less than $23^{\circ} 3'$. From this it is plain that the parallax, if it has any at all, is no greater than 3 minutes.

Proceeding therefore, as you know, by the Geometric method through the doctrine of triangles, there result 1061 $\frac{22}{74}$ [1061 and $\frac{22}{74}$] semidiameters of the earth, which is the distance of this comet from the surface of the Earth.

And from this it appears that the comet is set in the highest part of the Sphere of Venus, and barely nine semidiameters of the earth below the Sphere of the Sun. From which it is most certain that it plainly did not exist in the elementary region.

This location of the comet, moreover, we investigated diligently not only from observations on the meridian but also elsewhere, both this side of and beyond the meridian; and our observations agree entirely, by which we find its true place in the Zodiac to be P. 6. $\frac{58}{58}$ [$6^{\circ} 58'$] of Taurus, with a latitude of $53^{\circ} 36'$, or thereabouts. For we investigated the longitude and latitude not by painstaking calculation, but with the aid of a Globe and a clock justified by it.

And throughout the whole time that this comet endured, we found that it did not move or vary, even by a minute, with respect to longitude or latitude.

As for the difference of longitude and latitude that exists between our observations and yours, we have attributed it to this cause: that your observations were perhaps drawn up according to the common reckoning from the tables of the Fixed Stars, whereas we drew up our observations from the restitutions of the Fixed Stars, which vary widely from the tables.

For example, the Tables of Cyprianus [Cyprianus Leovitius] place the Eye of Taurus in $2^{\circ} 49'$ of Gemini, with a southern latitude of $5^{\circ} 10'$.

Our observation places the same star in $4^{\circ} 8'$ of Gemini, with a southern latitude of $5^{\circ} 35'$. The Tables place the Right Shoulder of Orion in $22^{\circ} 9'$ of Gemini, with a

southern latitude of 17° 0'. Our observation places it in 23° 10' of Gemini, with a latitude of 16° 13'.

Again, the Tables place the Great Dog [Canis Major, Sirius] in 7° 49' of Cancer, with a southern latitude of 36° 10'. But our Observations place the same in 8° 28' of Cancer, with a southern latitude of 39° 33'. From this difference in the Fixed Stars, that discrepancy of observations perhaps arose.

Furthermore, as for what you report about the diminution and color of this comet, we have observed the same here by a similar reckoning. Indeed, we would even say, in a manner of speaking, that it is again increasing a little.

What God may have wished to signify by this portentous star, time will tell. And we have judged that we should not fail to convey all these things to you with kindly and benevolent goodwill, and to entrust them to you point by point, so that you might also come to know our own speculation. And we are affected toward you with singular goodwill. Given at Kassel, the 14th of January, in the year 1573.

That this star was something supernatural, and foreign to and different from the nature both of the Meteors which are generated in the elementary region and of the comets — this the most illustrious Prince Wilhelm pronounces most correctly in these other matters, in the letter given to Peucer. As for the fact that the natural philosophers have hitherto thought that the heavens do not admit new bodies, this came about through a certain ignorance of the procreation and location of comets, and because they have bound themselves too closely to the Aristotelian decrees. So too many other things still lie hidden and concealed in the nature of things, though they are thought sufficiently understood by ordinary philosophers.

As for the fact that his Highness imputes the excessive deviation in defining the parallax of the comet to a fault of his instrument among the Wittenberg men — that this was said not without reason, I have no doubt at all. For they used a certain wooden Quadrant, by now nearly worn out through great age, and besides not sufficiently finely and neatly wrought in the other respects required, with more confidence than was warranted. But the instruments of the most illustrious Prince were by far more excellent and accurate — although he himself afterward noticed that not even with these could the utmost precision be brought down from the heavens to within three or four minutes. For this reason too, at the prior direction of Wittich [Paul Wittich] — who having shortly before been with me had seen these things here (for that man had been with me a little earlier) — once he had restored those instruments to the pattern of mine, both as

to the subdivision crosswise and as to the arrangement of the Pinnacides [pinnacidia, sights] by parallel slits, he found that an observation could be conducted in half a minute, and indeed to a quarter of that, far more accurately than before — whereas previously he had scarcely attained reliable certainty to within five minutes. Just as the most illustrious Prince himself, writing on this matter to the most distinguished and noble man D. Heinrich Rantzau [Henricus Rantzovius] of Breitenburg, vicar of the King in Holstein and the neighboring provinces, a man most eager for astronomical matters, bears witness:

he also attests, in a letter sent to me on this very point, that the instruments he used in observing the New Star did not exhibit so exact a precision—a thing he candidly admits—and that for this reason he later took care to have them rebuilt. The first volume of the *Astronomical Letters* will offer these letters for inspection regarding the beginnings of the matter. It is therefore no wonder that His Highness, at that time, was off by three minutes in his measurement of this Star's parallax, since an error of that kind easily creeps in on its own from the smallness of the instrument—especially when no sufficiently large instrument is at hand.

As for the altitude of the pole that he assigns—as before, $51^{\circ} 18'$ [P. 51. /18.]—I wonder how he arrived at exactly the same value both by means of the solstices and by the circumpolar stars, as he reports. For the reasoning derived from the Sun at the solstices, however the Star's parallax is applied, proceeds in such a way that, on account of the refraction—which at the low winter altitude is by no means negligible—it cannot yield exactly the same elevation of the pole as the stars revolving about that same pole supply from their greatest and least altitudes. So much so that here, in our own horizon, the discrepancy arising from this cause of the Sun's refraction—of which I have spoken—creeping in, somewhat exceeds four minutes. Now, although the Sun at Kassel near the winter solstice stands at an elevation of $4\frac{3}{4}^{\circ}$ [$4\frac{3}{4}$. Grad.]—higher than here—nevertheless it too acquires at minimum a refraction of 7 minutes [7. m.] at that point. I say nothing of the fact that the circumpolar stars in the tail of the Great Bear are there rendered so low that they too furnish some refraction; in particular the outermost star of that tail, which is raised no full 13 degrees [13. Grad.] when, in the horizon of Kassel, it occupies the meridian below the pole. And in so low a position it is by no means free of all refraction. Hence it furnishes the pole's altitude somewhat greater than it should be—just as became clear to us with those circumpolar stars which we employed earlier, in Chapter 4 [cap. 4], for thoroughly investigating the polar elevation of a place near Augsburg [Augustam Vindelicorum]. For those stars which stand only a little above the horizon at their

lowest altitude rendered, because of refraction, an elevation of the pole half a minute greater than it should be. The Pole Star itself—from which this inquiry proceeds most safely—at both altitudes, together with the other stars that closely approach the horizon, distinguishes and confirms this very point.

Afterward, however, the most learned mathematician of the most illustrious Prince, Christoph Rothmann [Christophorus Rothmannus], found by means of those same instruments—once restored—that from the Pole Star itself, as well as from other stars not too greatly inclined, the altitude of the pole of that place is $51^{\circ} 19'$ exactly [51. Grad. 19. m.], beyond the full integers—just as we too indicated earlier. From this it is also plain that the instruments which the illustrious Prince and Landgrave [Princeps Landgravius] once relied upon in measuring the New Star did not exhibit exact precision to within one or two minutes. Nor do I doubt that, if His Highness had at that time had at hand instruments such as are now available, he would have examined this unusual Star still more closely with them, and would, on the clearest evidence, have found it subject to no parallax whatsoever, and would have declared this very thing along with us.

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of the place of this New Star with respect to longitude and latitude (which here he notes to be the same as I had earlier indicated in the latter part of the preceding letters)—what I thought at that time I have already stated, and I compared it with my own finding.

His Highness rightly attributes the erroneous determination of the New Star's place to the incorrect positions of the fixed stars—though it is not gathered from Peucer's letters whether he proceeded in this way, by inquiring after the place of the New Star through the neighboring fixed stars. Yet if he sought it out from a transit across the meridian, given the declination and the moment of time, he could nonetheless, on account of the place of the Sun not having been sufficiently explored beforehand and the deceptive indication of time, have committed some aberration. And these two things doubtless caused the Prince trouble in determining the place of the Star, as can be sufficiently seen from His Highness's own observations enumerated in the preceding chapter and brought back to the anvil of the demonstrations and the numbers. For they are not everywhere consistent among themselves, a discrepancy of considerable size sometimes intervening.

The positions of three illustrious fixed stars, which he sets down here by way of example to show how far the calculation of the tables departs from celestial observation, are, as I judge, reduced to the year 1570 [annum 1570]. For when I visited the most illustrious Prince at Kassel in the year 1575 [Anno 1575], His Highness shared with me a certain catalog of some of the principal fixed stars verified by himself, drawn up in the year 1567 [Anno 1567], in which I find these stars in pairs differing by two or three minutes as to longitude from the earlier ones—although in Aldebaran there is no discrepancy of that kind. I therefore conjecture, with probability, that he adapted as to longitude the stars he cites to about the seventieth year [ad septuagesimum... annum], two years before the appearance of the New Star. And it is indeed certain that the Alphonsine calculation—which that most renowned and learned man Cyprian Leovitius used in his work of *Ephemerides*—departs very greatly from the celestial positions of the fixed stars. Yet the longitudes cited by the Prince, Cyprian reckoned to the year 1556 [Annum 1556], fourteen years earlier [14. Annis anterieus], in which, according to the mind of the Alphonsines, the fixed stars advanced very nearly 7 minutes [7. m.]; and these, though added to Cyprian's calculation, do not even so sufficiently extend their places. Indeed, not even the Copernican restitution itself satisfies this matter exactly, though it sometimes comes a little nearer the mark.

I shall, however, set out in the table below the corrected positions of the most illustrious Prince in these three stars for the year 1570 [Annum 1570], as I judge them, and to these very ones I shall join our own restitution for the same time; and I shall compare both with each other, and also with the Alphonsine and Copernican calculation.

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Determination of the places of three fixed stars for the year 1570, from the verification then made by the most illustrious Prince Wilhelm, Landgrave of Hesse, with our own finding applied to the same, and likewise the Alphonsine and Copernican computation.

Designatio loci trium Fixarum Stellarum ad Annum 1570, ex Illustriss. Principis Vuilhelmi Hassiæ Landgrauij tunc facta verificatione, adhibita nostra in iisdem inuentione, tum etiam Alphonsina atq; Copernicea supputatione.

ACCORDING TO [IVXTA]

NAME	RESTITUTION	RESTITUTION	RESTITUTION	RESTITUTION	CALCULATION	CALCULATION	CALCULATION	CALCULATION
S OF THE STARS	Prince's [Principis Vv. L. H.] Longit. P. M.	RESTITUTION — Prince's Latit. P. M.	— Our own [Nostram] Longit. P. M.	RESTITUTION — Our own Latit. P. M.	N — Alphonsine [Alphons:] Longit. P. M.	CALCULATION — Alphonsine Latit. P. M.	N — Copernican [Coperni:] Longit. P. M.	CALCULATION — Copernican Latit. P. M.
Aldebaran [Aldebarora]	4° 8' II [II]	5° 35'	3° 47¼'	5° 31'	2° 56' II [II]	5° 10'	3° 48'	5° 10'
Right shoulder of Orion [Dext. hū. Or.]	23° 10' II [II]	16° 13'	22° 47'	16° 6'	22° 16' II [II]	17° 0'	23° 8'	17° 0'
Canis Maior [Canismaior]	8° 28' ☿ [GG]	39° 33'	8° 8½'	39° 30½'	7° 56' ☿ [GG]	39° 10'	8° 48'	39° 10'

In Aldebaran, then, the most illustrious Prince exceeds our finding by about a third of a degree in longitude, and by at least 4 minutes in latitude. The Alphonsine value falls short by eleven-twelfths of a degree [gradus deuncem]. The Copernican value squares well enough at this point—though that holds, at least, only by accident in this Star. In latitude, however, the Alphonsine falls short by a third of a degree just as before. So too in the rest a clear discrepancy is found, as is evident from inspecting the appended table. The illustrious Prince has everywhere roughly a third of a degree more in longitude than we do; in latitude the discrepancy is not very great.

But as to why His Highness at that time differed so much from our observations—which I know to be accurate and subject to no fault—there was a sufficiently evident cause: the less exact mean instruments he then used. For afterward, with

the instruments restored and more perfectly worked out, he found the positions of these stars, and of others too, very nearly as we do, so that in the longitudes a discrepancy of scarcely five or at most six minutes occurs—just as, on one occasion when this was being done, we noted in Chapter 2 [cap. 2]. In latitude there is no discrepancy of any moment between our respective observations: for the most part we agree within one or two minutes. But the Alphonsine and Copernican reckoning departs both from our findings and from the whole heaven itself—as the saying goes—by nearly a whole sky.

Concerning the change in magnitude and color of this Star, which he adds last...

[p. 618]

he subjoins at the end exactly as the most illustrious Prince and Peucer reported them as happening. As for the Prince's opinion that the Star at that time began somewhat to increase—namely around the middle of January [Ianuarii], when those letters were written—perhaps it appeared so on account of the interposition of some less purified intervening medium in the air. For of itself this Star, from the time it began to wane, was diminishing little by little—though rather slowly—and admitted no fresh increase again.

But to the Landgrave's letters I shall not now append more—to which, if that learned man Peucer made some reply, as is credible, it has not come into our hands; otherwise I would have inserted it here as well. Therefore, in their place I shall append what his son, of the same name as the father, proposed shortly afterward at Wittenberg [Vuitebergæ] in a certain public disputation [promotione], together with the reply of the most learned M. Wolfgang Schuler [M. Vuolfgangi Schuleri], at that time professor of mathematics in the same University. And once these have been duly weighed, I shall turn to discussing the opinions of others.

A question proposed by M. Caspar Peucer in a certain disputation at Wittenberg in the year 1573, on the 5th day of March.

Quæstio proposita à M. Casparo Peucero in Promotione quadam Vuitebergensi Anno 1573. die 5. Martij.

I do not think it necessary to excuse myself for beginning to speak in this most distinguished assembly, since I do so both at the bidding of those to whom I owe obedience, and because it is publicly agreed that my Teachers, who have honored

me, require this of me. Therefore I only beg my hearers to look kindly upon my effort in discharging my office: for everyone knows what sad impediments are thrown in my way at this time against composing and writing anything worthy of an audience's attention. But what I lack in matter will be made up for by the subject, taken up for treatment because it is [Greek: ἀξιόλογον (axiologon, "worthy of mention")], and by him who is to reply to me, in learning and erudition.

Since, then, a question is to be raised, nothing could be asked of me that we should all more universally desire to hear, learn, and be taught, than if something be said and—as we trust—explained about that prodigious thing which now for the fourth month is beheld in the form of a Star by us, and (as I think) throughout all Europe. Nor does anything better befit us at this time, in our gatherings, to inquire into and learn, if we wish to avoid the charge of profanity and to render to God and to our schools the fruits of pious teaching and of pious erudition.

So wonderful and new are all things in this matter that I cannot myself determine how to name this [Greek: τέρας (teras, "portent")]—much less what it is. Should we call it [Greek: ἐνυπόστατον (enypostatōn, as set for enypostatōn, "having real subsistence")] or [Greek: ἀνυπόστατον (anyypostatōn, as set for anyypostatōn, "without real subsistence")]; or [Greek: οὐσιώδης (ousiōdēs, "substantial")] and [Greek: φασματώδης (phasmatōdēs, "phantom-like")], that is, [Greek: ἔμφασιν (emphasin, "a reflected appearance")]? And if it has real subsistence [hyphistamenon], is it a new Star, or something derived from some fiery meteor? It would be tedious to inquire into each point, and one thing comes into one man's mind, another into another's; let part of these individual matters be discussed, and it befits me rather to hear the reasoning of my Teachers on these things than to put forward my own. Yet I shall follow what is most agreeable and is supported by the greater number—that it is not a [Greek: φάσμα (phasma, "phantom")] or [Greek: ἔμφασιν (emphasin, "reflected appearance")] but [Greek: ἐνυπόστατον (enypostatōn, "a thing of real subsistence")]; and that the Star is such as is named by the Greeks an [Greek: ἀστήρ κομήτης (astēr komētēs, "comet-star")] or [Greek: πωγωνίας (pōgōnias, "bearded star")]—that is, a bearded [star]...

or some bearded or tailed star, when these too are not true stars. According to this, then, it will be a "miraculous appearance" [Greek: ἀστήρ τερατώδης (astēr teratōdēs, "a prodigious/monstrous star")] — a star of some marvelous and prodigious kind, a portent or omen. For it can also differ in its very kind from those bodies that are commonly called comets, on account of the form in which it appears. Although in every respect it is similar to those bodies that are properly

called stars — whether the wandering stars [planets] or the fixed stars — no comet is ever recorded in any monument of past ages to have lacked a coma or a beard, such as the eye could until now recognize, or by which it could be judged: unless from now on it should perhaps display something of the sort. Therefore it cannot until now be called either a κομήτης [Greek: komētēs, "comet"] or a πωγωνίας [Greek: pōgōnias, "bearded star"] on the evidence of the eyes' own perception. For since only two kinds of comet are known to be described by Aristotle [Aristotle] — one of which is called the "comatic" kind, which has a flame spread round about it on every side; the other the "bearded," which casts or extends this flame in one direction, upward or downward, or to the right or left, and sometimes even in both directions at once — and to this is added that this star [Greek: τέρας (teras, "portent")] has remained wholly motionless until now: it is not found to have stirred at all from the place where it was first seen, which is not the way of comets. And although we may suspect that the same happened with that famous star over Jerusalem — that it nowhere moved, but perpetually hung over that one place whose overthrow it portended — yet this star too, by its very immobility, differs even more, and from the length of time it has lasted: its burning has now endured a full year, whereas no other ["miraculous appearance"] [Greek: τερατώδης] is recorded to have lasted so long. But this star, as it now appears, a "prodigious star" [Greek: τερατώδης ἀστήρ], differs in nothing more from the class of comets, and has nothing more in common with them [Greek: τερατωδέστερον (teratōdesteron, "more prodigious")], than the altitude of the place in which it remains fixed.

And that it is placed in an exceedingly lofty position is proved by its tremulous brightness, even to those who reason from common-sense perception, since it is among the examples of Aristotle's demonstrations [Greek: ἀποδείξεις (apodeixeōn, "demonstrations")] that the planets do not "twinkle" [Greek: στίλβειν (stilbein, "to twinkle/scintillate")], precisely because they are nearer to our sight than the fixed stars. But from the agreement of their observations, various practitioners, drawing on the various locations they observe from, conclude that this prodigious star of our own time, raised so many semidiameters of the Earth above the Earth, is higher than the Moon — this cannot be doubted, however great the Moon's distance is said to be by Ptolemy [Ptolemy], [Greek: τηρήσεων ἀσθένεια (tērēseōn astheneia, "the weakness of the observations")] — since until now no comet has been detected that was more than nine semidiameters distant from the Earth.

Many have until now laughed at it as incredible that Proclus [Proclus] notes somewhere that a certain comet was once seen above Jupiter — though in this he

could not have been mistaken, if that comet was in conjunction with Jupiter: for the eye could then have shown this. But if there was no conjunction, how could that philosopher have communicated it to us, how could he have determined that it was higher than Jupiter? What no one has until now believed Proclus on — that anything of such fiery substance could burn above the Moon — is now proved by this prodigious star of our own time [Greek: ἀστήρ τεατώδης — set thus, the ρ dropped at the line break], which, whether it lies in the sphere of Venus, or higher, or lower, undoubtedly is higher than the Moon, and has its place in the region called "the ethereal coast" [aethereae orae].

But here is the real difficulty: what we have until now learned from Aristotelian philosophy about comets and meteors, and in following the schools have held, is all thrown into confusion. For Aristotle held that the ethereal region is immune from all the things out of which meteors are formed: that no vapor, which is the material of meteors, rises that far, nor penetrates the highest element. This dogma of Aristotle, and that Proclus — if the account is true — and this prodigious star of our own time [Greek: τερατώδης ἀστήρ] refute.

And although, concerning this Aristotelian distinction between the ethereal and the elementary region, certain men, before our time and in recent years, learned men of Italy and France too, have begun to inquire,

and to call the matter into controversy, so that their disputes are still unsettled — yet nothing can be brought forward that more overturns Aristotle's arguments than if a present fire should be demonstrated to burn in the ethereal region [Greek: ἀστροειδ[?]] (astroeid-, "star-like"); the small raised final sort is illegible]. Aristotle may yet be forgiven, however, since no such thing had been detected before his time, neither this one nor any other, whether of a different kind, or a change. For in our times, among other things, the maximum declination of the Sun is found to have changed, and the obliquity of the Zodiac [Greek: λόξωτις (loxōtis — set thus with a tau, for loxōsis, "obliquity")] to have grown smaller. And though that philosopher rushed headlong into his opinion, persuading himself that the heavenly bodies there are eternal and subject to no change, because he held the world to be eternal to him — from which it would follow that God, and in this way the Maker of the world and of heaven, would become an idol; yet in this he first took his stand: that if any change should occur in that supreme element itself, a fiery meteor could come to be there [Greek: δυνάμει ... ἐνεργεία (dynamēi ... energeia, "in potency ... in act")] for Aristotle. But how could anything of the sort happen above even this element, or break in by means of any vapor or any "exhalation" [Greek: ἀναθυμιάσεων (anathymiaseōn, "of

exhalations"]], a thing that cannot pass out of its own region? Unless, following Homer entirely, we introduce a heaven wholly of bronze, and bodies of the ethereal coast so compacted that they have no pores at all. But this in turn has its own difficulties [Greek: ἐνστάσεις (enstaseis, "objections")].

That our star is, however, a "prodigious" one [Greek: τερατώδη — accusative, as set], and neither of the kind of those stars that are simply so called, nor of the kind of these [comets], this it has in common: that before our time there was none there, and that from the time it began to appear it has manifestly diminished, and the body of it has grown thin and become less. And so it is, indeed, that it seems to have been unable to come into being from the mere opposition of the Sun, and from an error of the eyes, that greatness of it with which it first appeared. Its color, too, now seems to have changed already twice.

This too has come to mind: that it might be possible for it to be an Aristotelian "comet" [Greek: κομήτης (komētēs, "comet")] — that is, one which has a flame spread round about it in a circle: and yet, on account of its very great altitude, the hair of the flame cannot be distinguished by the eye from the body, or the hair is so fine that at so great an interval it is not recognized.

All these things therefore being considered — whether it can or ought to be called a comet, or rather a prodigious star [Greek: τερατώδης], or whether, against Aristotle's arguments, a fire of this kind can be kindled in so lofty a place, and above the Moon in the ethereal region; and whether it can be excited there in the same way, or in a different way, than in the elementary region — there are many reasons for us to be in doubt.

Since, then, I myself can determine nothing, it behooves me to seek out the reasons and the opinion of my teachers. I therefore reverently beg the most excellent mathematician, Master Wolfgang Schuler [Wolfgang Schuler], to teach me and the audience about these matters and about this miraculous star, the like of which no age is recorded to have had; and because both he himself and his colleague have observed it — since their diligence in this is publicly known — and because we know that they have devised and elaborated special instruments for a more exact observation of it. Likewise, that he may share with us the learned observations of others, and his judgment concerning these things. I also beg this most learned man to say something about the significations of this star: especially since there are some who proclaim from it happy times and a golden age, increasing the security and impiety, and the tyrannical schemings, of our enemies — when no comet has ever signified good events. The one Seneca [Seneca], flattering his pupil Nero, predicted from a comet of that time a good

outcome from that emperor — who afterwards ordered this same teacher of his to die: such an outcome perhaps awaits those prophets too, who increase the security and impiety of men.

It remains for us to hear you, our esteemed teacher, and your learned and pious disputations on the greatest of subjects, which the whole audience awaits most eagerly. I have spoken.

RESPONSIO M. WOLFGANGI SCHULERI.

[The Reply of Master Wolfgang Schuler]

They say that Epaminondas [Epaminondas], the most praised general of the Thebans, declared that of all the noble and honorable deeds he had performed in his life, this was by far the most delightful to him: that, with both his parents still living, he had conquered the Lacedaemonians in the memorable battle of Leuctra. So too I do not doubt, most learned Master, that nothing is dearer or more desirable to you than that your dearest parent, a most distinguished man, should have been present — indeed, should have presided over this public assembly, in which you and the rest of the "fellow-sufferers" [Greek: συμφοιτηταί (symphoitētai, "fellow-students")], now according to the laws of the School, have been adorned with the most honorable degree of Master. Nor do I think anyone so ungrateful a pupil that he would not at once long for this together with you. I, for my part, in this solemn festivity, in which the public proclamation has been made, sigh for your dearest parent, like a scholastic assembly, [Greek: ὀφθαλμὸν καὶ μάντην ἀγαθῶν (ophthalmon kai mantēn agathōn, "an eye, and a good seer")], with an anxious turning of my eyes, with a groan of true voice, and with an anxious heart.

But although, hindered by ill health, he cannot be present in person, yet we know for certain that, though absent, he joins his vows with ours for the preservation of this Church, of this most renowned Academy, and of the civil order.

Therefore in turn, with our whole heart, we give thanks to God that, amid so great a mass of cares and occupations, and amid so great a weakness of a body worn out by public labors, he has until now preserved your parent for this Church and for this Academy; and we ardently pray that He may preserve him still longer. Would that it had been granted by God that your dearest parent might have answered you, his son, on a matter so grave and so very difficult to investigate: for I remember that this falls to others by the same circumstance. He could himself, by his authority — that authority which is strong enough — have

refuted the folly and impiety of the many who now scatter whole wagonloads of trifles among the crowd; and we too, who are endowed with such skill of judgment as we have, he could rightly have instructed about the present portent. As for me, although I have neither learning nor even a middling capacity for speaking — and so I clearly perceive that I am unequal to this burden — yet, that I might not seem unwilling to shirk the burden of public labors, and to fail the studies of the young and the mandate and will of my teachers: therefore, that you may bear with me as I speak about the present meteor, it will be fair for your goodwill to support me. Since your great courtesy promises this of its own accord, I will, with longer apology set aside, proceed to the matter itself.

There are two things proposed to me by the most learned Master to be explained: one, that I should render an account of our observations; the other, that I should say a few things about the portent that has now been visible for as long as four months — whether it is that "meteor" [Greek: μετέωρον (meteōron, "meteor/thing aloft")], or rather a star; in what place it is situated, whether in the ethereal or in the elementary region; and lastly, what and what sort of things it signifies.

Of our observations I shall speak first. After, between the sixth morning hour of the sixth day of last November, in the year 1572, a comet was first seen by us, not far from the asterism of Cassiopeia [Cassiopeia], we at once set ourselves, equipped with astronomical instruments, to investigate its declination, its distance from the pole of the equator, its right ascension, its apparent place in the ecliptic, its latitude, its parallax, and the rest of what is necessary for knowledge, relying on sure and evident traces of demonstration. I have said this must necessarily be added, lest anyone should suspect that we — as many incompetent men now do — have rashly invented something without demonstration. We undertook very many observations: of which, however, on account of shortness of time, we have decided to report only two here. The first of these fell on the morning hour of the 27th day of the month of November of last year. We proceeded in the following manner:

Since this comet neither sets nor grazes the horizon, but describes a course nearly parallel above the horizon, always remaining visible, it is clear by propositions 28 and 29 of the second book of Theodosius [Theodosius] that it has two meridian altitudes, one the greatest and the other the least. Therefore, with a quadrant instrument aptly and neatly fitted to the meridian hour, we waited until the comet should fall upon the meridian itself: which happened a little before the seventh morning hour. And we found the greatest distance of the comet from the zenith to be 66 degrees 27 minutes. Hence its least altitude above the horizon was

23 degrees 33 minutes. And since the most distinguished men, Dr. Cruciger [Caspar Cruciger] and Reinhold [Erasmus Reinhold] — both of pious and holy memory among us — by several sure observations of "the pole of the equator" [Greek: τοῦ πόλου ἕξαρμα (tou polou exarma, "the elevation of the pole")] at Wittenberg [Wittenberg] found it to be 51 degrees 54 minutes, the declination of the comet in this morning observation will be 61 degrees 39 minutes, and its distance from the pole of the equator 28 degrees 21 minutes. The greatest meridian altitude of the comet, however, was 80 degrees 15 minutes.

From these things, thus found by sure traces [Greek: ἐφόδῳ (ephodō, "by the method/approach")] of calculation — which I now pass over — we investigated all the rest: namely the right ascension of the comet at the prescribed time at which the comet occupied the meridian, which was found to be 179 degrees 10 minutes, to which corresponds in the ecliptic the part of the bull [Greek: μοῖρα μεσουρανοῦσα (moira mesouranousa, "the degree culminating")], as Ptolemy calls it, 29 degrees 53 minutes, at the comet's least altitude above the horizon. Hence it is clear that the circle of declination, which is drawn through the center of the comet, is distant from the colure of the equinoxes — numbering through the comet's culminating points [Greek: εἰς προηγούμενα (eis proēgoumena, "into the preceding [parts]"); breathing uncertain] — by only 50 minutes. Further, with three things given — namely the distance between the poles of the equator and the ecliptic, the declination, and the right ascension of the comet — the doctrine of spherical triangles reveals the apparent place of the comet to be in 36 degrees from the vernal intersection, that is, in 6 degrees of Gemini [dodecatemory G [recte: 6° Gemini]], and its northern latitude to be 54 degrees 3 minutes. This was the first observation, with which a second also agrees, made on the 4th day of December, and several following days of the same year, which we have made. For in the least altitude we find no discrepancy at all.

But the greatest altitude found by the instrument falls short of the maximum which the calculation above, from the least altitude above the horizon, yields, by 19 minutes for the first ones. For we found in the evening time of the same day the greatest elevation above the horizon on the meridian to be 79 degrees 56 minutes, and the least distance from the zenith 10 degrees 4 minutes. From these data it follows, by the same doctrine of triangles, that the longitude of the comet in the evening was seen in 6 degrees 25 minutes [of Gemini], with a northern latitude of 54 degrees 16 minutes. Hence we have reasoned that the parallax of the comet is only 19 minutes. For in the evening time, since the comet approached as near as possible to the zenith, it is likely that it is free of parallax, and that its apparent place then coincided with its true place. But when it was set

on the meridian in the morning and most remote from the zenith, it is certain that it had the greatest parallax of all.

Thus, with the parallax found by means of plane triangles given with three angles in a rectilinear right-angled figure, we find the distance of the comet from the center of the Earth to be so great that — whether we follow the hypotheses of Ptolemy or of Copernicus [Copernicus] — it seems it must be placed above the sphere of the Moon. To these our observations (excepting a few minutes for the first ones) correspond the observations [Greek: παρατηρήσεις (paratērēseis, "observations")] which the most illustrious prince, William, Landgrave [William IV, Landgrave of Hesse-Kassel], instituted at Kassel in Hesse, and certain others in Prussia and Silesia, and, as I hear, at Tübingen. For all agree in this: that the present comet, having left the elementary region, has migrated into the ethereal — although some count more, some fewer, semidiameters of the Earth.

We cannot depart from our own observations: both because, with moderate diligence applied, we saw and detected them with our own eyes; and also because the semidiameter

exceeds the size of our own quadrant by a semidiameter of the quadrant they used at Kassel, in roughly double proportion. I make this point because it is certainly established—it is, as it were, an axiom in mechanics—that the larger the instruments by which the positions of stars or comets are taken, the more reliable the observations. And yet, if we are convicted of error (for to err and to slip is human), we will not stubbornly and ambitiously defend our own opinion. Rather, I always recall that fine saying which Ptolemy quotes in Book 5 of the τῆς μεγάλης συντάξεως [Greek: tēs megalēs syntaxeōs, "of the Great Composition"—the *Almagest*]; I have thought it worth adding here so that everyone may have it before them: "Since this is a divine profession, those people judge wrongly who, while they seek the truth, think it shameful to be corrected by others, or to amend something themselves." Following this precept of Ptolemy, in order that no doubt whatever might remain to us concerning the parallax, we have constructed yet another instrument—with straightedges, or parallactic, like Ptolemy's—found by us repeatedly with consistently equal results, and large enough. For its two equal sides are each about ten feet long. From now on we will take pains, whenever the sky is clear and the winds do not interfere, to set up παρατηρήσεις [Greek: paratērēseis, "observations"] which will either confirm or correct the earlier ones.

This much I have briefly set out concerning our little account [historiola] of the observations, and concerning our intention—to the young students, in order to

answer the first part of your question. I was directed to do this by my teachers, to whom the governance of public studies in this school has been entrusted.

I now pass to the second matter, in which these three things are inquired into: whether the thing displayed is a star or a meteor; in what region—the elementary or the ethereal—it lies; and finally what it signifies, and what it portends in particular. On each of these I will say a few words. That the present phenomenon is not to be reckoned among the planets is too well known to need much discussion here. Still, I will offer a few brief but firm demonstrations. No age has ever numbered more than seven planets [stars that wander]. And it is the property of the planets to move by their own motion εἰς ἐπόμενα [Greek: eis hepomena, "toward the following signs"—i.e., eastward; set thus, without the article], from west to east. But this phenomenon, from the moment it was first seen by us, has stood not far from the asterism of Cassiopeia, together with three stars of that constellation—of which one is in the breast, another above the chair at the thighs, the third at the middle of the back (in the ascent)—or, of the three, one is the second in the order of this constellation, another the fourth, the third the twelfth; all are of the third magnitude. We have been unable to make it conform [to a planet] σχῆμα ῥομβοειδὲς [Greek: schēma rhomboeides, "a rhomboid figure"], and up to the present day we have observed with our eyes that it has not changed the figure described. Therefore, since it always stays in one place, and follows so closely the turning of the primum mobile, it will not be a planet.

Furthermore, although a planet does not always travel beneath the ecliptic, as the Sun does, but ranges beyond it on either side, nevertheless craftsmen have observed that there are fixed bounds—as it were limits and terms—on both sides, toward the south and toward the north, of seven degrees, which they never cross. But this phenomenon, or τέρας [Greek: teras, "portent, marvel"], as the παρατηρήσεις [Greek: paratērēseis, "observations"] of those above indicate, is removed extremely far from the ecliptic toward the north—so far that this distance has roughly eightfold the proportion to the greatest digression of a planet from the ecliptic. For the observations teach that its northern latitude is 54 degrees 16 minutes. From this it is again concluded that it cannot be a planet.

Moreover, it is not characteristic of planets to twinkle or to have a tremulous light, which we have noticed with our eyes in this phenomenon. Therefore on this account too it is removed from the number of the planets.

Yet it is not to be reckoned among the fixed stars either, on account of its twinkling. For it differs from them by a striking distinction. For in no past age

have craftsmen ever detected more than 13 stars in Cassiopeia: recently this one was added as, so to speak, a 14th—but with a bright,

clear, and pure light of its own—not only surpassing the stars of Cassiopeia, but even Sirius itself, the brightest of all the stars fixed in the sky, at its first appearance. Then, [it differs] because the fixed stars do not change in magnitude, brightness, or color; whereas in this phenomenon we have seen the body gradually grow thinner, the light diminish, and the color, from a whitish and Jovial hue, turn gradually reddish and Martial.

From this we who reason certainly conclude that it is not a fixed star. It remains, therefore, that it is a meteor, and indeed one to be classed among the kinds of comets. For these alone present themselves to view over a long time, whereas the other fiery meteors blaze up suddenly. Hence, convinced by the most certain arguments, we affirm that it is a comet. Now we must inquire into the place we should assign to it. Here I enter upon a disputation in which my earlier statements seem to dissent from my later ones. Indeed, I confess that on no point is there greater difficulty than in investigating and grasping the place of the present comet. For if we determine that it lies above the sphere of the Moon, in the ethereal region—as our own observations and those of others teach us—then the Aristotelian doctrine of comets, approved by everyone for so many centuries, is overturned. But if we place the comet in a lower region, namely in the elementary region, then not only others but we ourselves err shamefully in our observation. Hence it comes about that this meteor compels many of us μετεωρίζεσθαι [Greek: meteōrizesthai, "to be in suspense, to be raised aloft"]—that is, to doubt and to suspend assent.

Let me briefly set out what I myself think; and if others bring forward more certain and better things, and also explode my opinion with firmer arguments, I am willing not only not to be angry with them, but even to be grateful that they have led one who erred back into the way. So, that this knot may at last be untied, let us approach it by this path.

Trained in the Aristotelian philosophy, approved through so many centuries and having fewer errors, I will by no means grant that slow and viscous exhalations rise from the elementary region into the ethereal region, and are kindled there, in the generation of a comet. As for a comet, I will by no means grant that, in its conflagration, it descends in turn from the ethereal region into the elementary, and there widely burns the air, and that its matter is the winds, and that it produces droughts and other physical effects. This, I say, I will by no means grant. For once that is granted, many absurdities follow. The interpenetration of

dimensions—as it is commonly called in the schools—would be conceded; and there would be fashioned for the celestial orbs passages or pores, as in mixed bodies—whereas sacred Scripture expressly names the orbs the Firmament, and the Greek interpreters στερέωμα [Greek: stereōma, "the firmament, the solid vault"]. The usual distinction received in the schools between the elementary and the ethereal regions would be overturned—a distinction which the very experience of so many thousands of years teaches: that generations, corruptions, and alterations occur through the primary qualities in the elementary region only, whereas the ethereal region is subject to no changes. And so, as it happens, when one part of a doctrine is moved from its place, the ruin of many parts follows. As for this new doctrine, wholly unknown to wise antiquity, I am unwilling to be its author in this most renowned Academy, nor to be reckoned its author—just as in matters of polity (fearing the custom and usage of the Locrians) I would not wish to propose a new law. For if there is anyone who would not wish to undermine the arts well built up from their first principles, I too declare my name among them.

What, then, is to be done, if later observations—both of others and our own, with all the diligence that can be applied—will not correct the earlier ones, but rather confirm them, so that very slight, or absolutely no, parallax is detected in the present comet? Here, just as certain αἰτήματα [Greek: aitēmata, "postulates"] are granted to the geometers, so we too will demand of the defenders of the Aristotelian doctrine that they not compel us to depart from our own observations and those of others, which we have seen and detected with our own eyes with the utmost diligence. This granted, [let them not compel us to depart] from the distinctions of the regions which

have been handed down by them; we will affirm that the present comet, or rather τέρας [Greek: teras, "portent"], is by no means to be numbered among the customary comets—those which a careful observation by craftsmen, and the experience of so many centuries, has detected to be driven together from viscous and slow vapors, or even by the ill-omened position of the malefic stars, into the elementary region, and at last inflamed and consumed—but is to be set apart from those customary ones as an unaccustomed prodigy.

This opinion of ours agrees both with the sayings and with the examples of sacred Scripture, which affirm and bear witness that God is in no way—as the Stoics' divinity is—bound to secondary causes. For although for the most part He preserves the order divinely established by Himself, nevertheless He can also change it, and sometimes does change it: as the delay of the Sun above the

horizon in the battle of Joshua bears witness, στηριγμός [Greek: stērigmos, "a standing still, station"] of the Sun in the battle of Joshua, and the going back of the shadow on the dial shown to King Hezekiah, and innumerable other things. To light and depraved minds no occasion is given of overturning the arts rightly handed down and well established, and of inventing whatever they please; rather, the customary doctrine of comets, received in the schools, is retained. And yet we do not deny that God sometimes, beyond the common order divinely established by Himself, displays τέρατα [Greek: terata, "portents"] or signs in the ethereal region.

To this class I judge is to be referred the comet which Proclus mentions in the commentaries he wrote on Plato's *Timaeus*. Although—to speak frankly and openly, yet candidly—what I think, I do not look for in Proclus, whom I know to have been a most learned man, but in that Anonymous one, whoever he was, from whom the things Proclus cites are described—the same things which many learned men in the historians of an earlier age, and especially among unlearned monks, [report]. For just as those men wrote the history of some war without inquiring what was the αἴτιον [Greek: aition, "cause"], or what the προκαταρκτική or αφορμή [Greek: prokatarktikē, aphormē, "the initiating or exciting cause"], or what the πρόφασις [Greek: prophasis, "occasion, pretext"]: so that Anonymous describes the comet without the times, the places, of the man who observed it or wrote about it by testimonies—since, in this part of philosophy, it is not enough to state the αὐτὸς ἔφα [Greek: autos epha—"he himself said it," the Pythagorean *ipse dixit*, i.e., bare authority]; but firm and immovable geometrical demonstrations are required. This way I judge to be the safest; nor, however, do I prevent anyone's own opinion from pleasing him—provided only he does not overturn the arts divinely shown, alleging a few particular examples which have sometimes, and indeed rarely, happened contrary to the rule.

There remains the last part of your question, concerning the significations of this comet. But this we will defer to another time. Now, since we recognize that fatal changes of empires are impending, and that these calamities are divinely foretold as the boundaries [or: as the limit of the world], let our Lord Jesus Christ be earnestly entreated with fervent prayers that at this very time He may fight for the sons of His people, defend them, and preserve them, so that they may not be utterly oppressed and extinguished by the Devil and his instruments. I have spoken.

What the not unlearned son of that most learned Peucer [Caspar Peucer] set forth in the assembly of the Wittenberg gymnasium was shrewdly brought forward,

and reflects the doctrine and the admonition of the father, from which the son does not seem to degenerate.

But to doubt whether this phenomenon was really something subsisting, or rather a phantom thrusting itself upon the eyes, was not necessary—since the very sense of the eyes, not of one man but of all who had sound sight, beheld it for more than a full year in the same place of the sky, motionless. Nor on that account was it properly to be reckoned among the comets—as he himself afterward rightly argues—but rather

it is to be called rather a portentous and new star. For it really was similar to true and genuine stars, nor (as he not unjustly asserts) was any comet ever beheld in such a guise: nor does it deserve to be admitted into the two Aristotelian kinds of comets, or even into the more numerous Plinian ones.

The Portent of the people of Jerusalem—though it persevered for a whole year, as Josephus relates, that distinguished writer of Jewish antiquities—makes nothing to the point here. For unless it had existed in the neighboring air, it would not have pointed perpetually to that city more than to others; as we have discussed earlier on this matter at greater length in chapter 3.

That he asserted this star to have been above the Moon was not inappropriate; indeed, even if he had raised it above all the other planets, he would have pronounced nothing alien to the truth. For this observation was not so thorny but that it lay open even to the external senses, with instruments and geometrical proofs applied. But in that he asserted that no comets had been detected, up to then or beyond, more than nine semidiameters distant from the earth, he seems on this point to cling too confidently to the Regiomontanian [Regiomontanus] annotation concerning the comet of the year 1475. This—because it was not complete in all its figures, nor reached the mark with sufficient certainty—will be plainly made manifest by us in its proper place. For my part, I [affirm that] all comets, in whatever form they finally appear, provided they obey the universal motion, are in the heaven itself, not below the Moon (which is nearest to us, at least 52 semidiameters distant from the earth), are generated; nothing do I doubt of it; and that those which shone forth some years before the preceding ones directed their course, without any hesitation, within the bounds of the ethereal region—I will, in the following volumes, and from sound observations, demonstratively give proof. But since nothing of the kind had become known to the alumni of the Academies—inasmuch as they consult books more often than the heavens, and are also destitute of the requisite means—through experience, it is no wonder that both this older Peucer and the younger one, and any others

trained in the universities, subscribed to the long-approved opinion; especially since, on the strength of that great Regiomontanus's observation in the said comet, they reckoned [it] to make for this opinion—not to mention Vogelin [Vogelin], the mathematician of Vienna, who brought yet another comet of his own age closer to the earth: both, however, deceived by carelessness of observation and forestalled by Aristotelian authority, just as many others elsewhere, in the comets of past years, concluded the very same thing apart from the fact—as will elsewhere be clearly made manifest.

If Proclus asserts that some comet was observed above the revolutions of Jupiter, he brought forward nothing absurd. Let them laugh who will; truth is not eluded by laughter. It could have been discerned from the excessive smallness of the parallax, and also from the motion and form—even if it was never joined to Jupiter degree by degree—so that on that account credit need not be denied to Proclus, so great a mathematician, even if he did not bring forward certain proofs into the open. For it is not likely that he pronounced this without evident reasons, since he undoubtedly was not ignorant of the Aristotelian tenets.

We have no hesitation in maintaining that comets can have their seats and dwellings within the orbits of all the planets, even of the highest, Saturn. We will offer proof and testimony of this in the later books, where we treat of these matters. Indeed, this New Star too was associated with the heavens of the eighth orb [Octavi Orbis Sideribus], above Saturn itself; and since there is no doubt that it shone forth so very high up, it is by no means absurd that even in a still loftier region of the heavens [aliqua Caeli Regione] some new phenomenon should be brought forth.

It is well said, and not without good reason, that this very star [Sidus] throws into utter confusion the whole Aristotelian philosophy of comets and meteors, taught and devoutly observed in the schools until now. In truth, since this star fights diametrically against the whole of Aristotle's doctrine, it demonstrates most plainly that the nature of the heavens is by no means as he supposed. If only those who frequent the academies — whether as teachers or as students — would take this star, or this opportunity, as an occasion to open their eyes for once, and to perceive from the very book of Nature with how many and how great errors that pagan Aristotle has for so many centuries now bewitched them! Then they would understand that very many of the things they daily repeat as settled and beyond doubt are in fact far otherwise. But somehow — by what fate it is that benights the earth-dwellers with errors and darkness, I do not know — it happens that what is wayward is taken for what is right, and what is implausible

is, for the most part, chosen and approved as fitting; indeed, it is bandied about on every side as if it were authentic. So it is even now in all the academies: the Aristotelian opinion concerning the generation and place of comets — though in no way consistent with their own experience — is approved and fiercely defended in order to uphold it. For they find it irksome and tedious to drop the old refrain, or rather the old ditty, and to warm up once more the cabbage so often cooked. Indeed, they hold it a sacrilege to depart even a finger's breadth from Aristotelian decrees, or to call them once into doubt. O what slavery!

That certain learned men of Italy and France [Itali atque Galli] have raised the question of how the region of the aether and the elementary region differ from what Aristotle asserted was not without good cause — as is now plain at last from the many phenomena appearing in the heavens that prove the point. Nor is Aristotle therefore to be excused for having taught that comets stray from the whole heaven. For there were men before him who held, more correctly than he, that comets are generated in the aethereal region; and these were without doubt distinguished mathematicians — Chaldeans, Egyptians, Phoenicians, Arabs, and even Ethiopians and Indians — who dwelt under a clearer sky and, devoting themselves unremittingly to the contemplation of the heavens, relied upon accurate observations. Yet Aristotle brought forward none of their findings to confirm his own opinion; instead, relying only on plausible conjectures, grounded in no celestial observation or geometrical demonstration, he tried to persuade men that the matter stood as he said, as though by some authority of his own — and not without prejudice to the ancients, who philosophized more correctly.

But when he does admit that some comets occasionally remain continuously attached to the fixed stars [Astris perpetuis],

he then builds, through his own ignorance, things contrary to himself. For it cannot be that some phenomenon existing in the elementary region should, beneath some celestial star, stand still throughout an entire daily revolution with perfect exactness — for parallax [Parallaxi] would then constantly introduce no small divergence, to say nothing now of the other absurdities that follow from this, better dealt with elsewhere. Thus the maximum declination of the Sun [declinatio Solis maxima], which in our age has become smaller than it was given to be of old, does not exonerate Aristotle, nor does it imply any alteration of the heaven through itself; rather, it arises from some other source — from certain peculiar laws governing the Sun's motion, of which we shall speak elsewhere, and which are perceptible only after many intervening centuries have passed.

He is right, nonetheless, when he affirms that Aristotle practiced a kind of idolatry toward the heavens, in that he held the creature in the place of the Creator. Yet this philosopher, so atheistic and idolatrous, is for so many years now worshipped in the schools as an authentic authority, as though he were a kind of demigod and deity.

His element of fire is nowhere to be found, so that in this matter, no less than in the very essence of the heaven and in the reality of the nature of the orbs, he has imposed upon us. It is therefore in vain that any proof is sought from this source for a celestial generation of comets.

That any vapors should break through into the heaven itself — granting that it is not endowed with a hardness like bronze — is inadmissible; nor would such vapors suffice for the formation of so great a body, or for the gathering of so luminous a mass, even if they were drawn together from the whole earth on every side.

That this star was in no way of the kind of true stars coeval with the world cannot indeed be denied, since it arose at an intermediate point in the world's duration, after the rest had been completed, and likewise ceased to exist. Yet it does not follow from this that it was in no way celestial; rather, since it was in most respects very like the other stars, it should be called a star rather than a comet. We have discussed this more fully in its proper place.

It could not have been an Aristotelian comet, of the kind that have a coma spread all around in an orb (which he wrongly calls a flame). For the senses of the eyes bore clear witness that nothing of this kind clung to it. Indeed, it would not have sparkled so brilliantly, nor flashed clear, translucent rays this way and that, had it been veiled with hair after the manner of comets. Nor does its great remoteness furnish a sufficient excuse here. For throughout its whole duration, on every side, this star remained free of all hair; and although it changed in magnitude and in color, it nevertheless looked at all times very like one of the bodies coeval with the world, and was never subject to any fibers, however slender, projecting in any direction. Therefore the assertion that it once displayed such hair is groundless, since it never appeared at all.

That some marvelous fire was involved is doubtful, and lacks any sound reasoning. For whatever burns is engaged in the perpetual consumption of its material, and therefore always craves new fuel; nor does it persist long in the same place and position unless violently held there. Much less, then, could it

remain for more than a whole year in exactly the same place, obeying daily the most rapid revolution of the universe.

But these matters concerning the question raised by the younger Peucer [iunioris Peuceri] — a view intermixed with it, which he no doubt drew from his father [Caspar Peucer] — I think I have examined sufficiently. Let us now consider what Wolfgang Schuler [Wolfgang Schuler] brought forward, in the place of a response, by way of his own observations made with instruments, which he reckons suitable for resolving this matter. For I am pleased to take up and answer only the earlier points, which he expresses rhetorically rather than mathematically, as he accommodates himself to the manners of the schools.

Disquisitio eorum Quae Wolfgangus Schulerus, in Publico Academiae Witebergensis conventu, responsionis loco ad Quaestionem de Nova Stella Propositam, respondebat.

[An examination of what Wolfgang Schuler answered, in the place of a response, at the public assembly of the University of Wittenberg, to the question proposed concerning the New Star.]

When he comes to the observations themselves, he says, after finishing his preamble, that this star was first seen there on the 6th day of November in the year 1572 — a star which he improperly calls a comet. This, at any rate, agrees well enough with our own view: that this star had its first beginnings around the time of the new moon of the 5th of November, the date from which I have judged it probable, by conjecture concerning its first rising, that it took its origin. He brings forward two observations. The first, from the 27th of November, when he says it was on the meridian, below the pole, at an altitude of $23^{\circ}33'$ [Polum Altitud. p. 23. / 33] — the same observation that Peucer also described in writing, both to the most illustrious Prince and to Hieronymus Wolf [Hieronymum Wolphium]. From this he concludes, applying a pole-altitude of $51^{\circ}54'$ [Poli altitudine p. 51. / 54] (which Reinhold and Cruciger [Reinholdo & Crucigero] long ago carefully discovered), that — calculated proportionally — the altitude must have come out to about $80^{\circ}15'$ [p. 80. / 15] near the zenith, a value he does not hesitate to assert. But when, in the other observation, of the 4th of December, he found the maximum altitude to be $79^{\circ}56'$ [p. 79. / 56], differing from this earlier one by $19'$ [m. 19], he infers that this star's parallax [Parallaxin] was just as great.

These results would, in a certain way, hold true on the basis of those data, provided he did not confuse the two parallaxes — both the one occurring near

the vertex and the one occurring near the horizon — when they ought rather to be kept distinct from one another.

But whether through a fault of the instrument, or through the elevation of the pole not being correctly applied, or indeed through both causes, this was committed; and here they have certainly strayed very far from the mark,

so that the observations of the Wittenberg men have departed by nearly a third part of a whole degree — which is indeed too much.

I judge, moreover, that this deviation arose so excessively, chiefly from this: that they assumed a pole-altitude greater than the true one. For the maximum and minimum altitudes of the star, compared with each other, show — through their halved difference, which is $28^{\circ}11\frac{3}{4}'$ [p. 28. / $11\frac{1}{2}$, recte: see parsing note] — the declination of the star, since this is its complement; and it differs by at least a degree and a half [sesquialtero scrupulo] from our own finding, as we noted once above, and warned again, and in the examination of the Hainzel letter [Epistolae Hainzelianae]. We establish the pole-altitude, from the maximum and minimum elevation of the star, as more probably $51^{\circ}45'$ [p. 51. / 45] or thereabouts — which we shall now also prove, by no idle reckonings, to be the more correct value.

The pole-altitude of Leipzig [Poli Lipsensem] was long ago found by Johannes Homelius [Iohannes Homelius], the distinguished mathematician of its university, to be $51^{\circ}17'$ [p. 51. / 17]. Wittenberg lies eight German miles from there. So if its line of position [linea positionis] tended due north, $32'$ would have to be added to determine the pole-elevation of Wittenberg. But not even on that assumption could one confirm their figure; rather, it would come out to at most 49 [minutes?] beyond the whole degrees, which falls short of the assumed reckoning by five minutes [quinis scrupulis]. Since, however, Wittenberg does not lie due north of Leipzig but reclines somewhat toward the rising of the sun by a third part of a quadrant — so that, with respect to the tract running out from Leipzig, it faces northeast [mesaquilonem], as all the more accurate geographical maps, and the itinerary of the journey itself, attest — we shall therefore inquire how much precisely must be added to the pole-elevation of Leipzig in order that Wittenberg's may come out more certainly.

Let it be understood, then, in the accompanying triangle: A — Leipzig [Lipsia]; B — Wittenberg [Witeberga]; C — north [Septentrio], with respect to Leipzig. Since the angle A C B is a right angle, and the angle B A C is given — for it is reckoned by the circle of position, by which Wittenberg differs from the northern line, that is, the meridian of Leipzig, in degrees of the horizon by a third part, as I said, of

one quadrant, and therefore 30° approximately — for no great precision is needed here.

Diagram. A right triangle illustrating the bearing of Wittenberg from Leipzig. The apex is at the top, with the right angle at the lower right.

- A (top apex): Leipzig [Lipsia]
- B (lower left): Wittenberg [Witeberga]
- C (lower right, at the right angle): north [Septentrio], with respect to Leipzig

The side A C runs from the apex down to the right-angle vertex; A B is the hypotenuse from the apex to the lower-left vertex; B C is the base.

There results, then, the side A C, which shows the difference by which the latitude of Wittenberg exceeds that of Leipzig — nearly $28'$ [Minut. ferè 28]. When these are added to the value observed at Leipzig by the aforementioned Homelius, it yields the truer elevation of the pole above the horizon at Wittenberg: $51^\circ 45'$ [p. 51. / 45]. This agrees more readily with the value we deduced earlier from the maximum and minimum altitude of this star as observed there, and renders Wolfgang's assumption invalid. From this it also follows that the star's parallax was by no means as great as the Wittenberg men derived from their own observations, by means of a less accurate pole-altitude.

Moreover, since this elevation was gathered from Homelius's [Homerius] Leipzig observation, and consequently also from our own Wittenberg observation derived from it, it deserves preference all the more because of the great care that Homelius brought to building and handling mathematical instruments mechanically. He did so to such effect that he even used the Nonian subdivision of quadrants [Nonniana Quadrantum subdivisione] — most ingenious, if only he had it ready at hand; what he had access to was promised. This makes it probable that he investigated this maximum and minimum [solar] altitude diligently by the Sun's maximum altitude. I came to know this myself, since some 25 years ago, more or less, I lived at Leipzig for the sake of my studies. [Margin: When Tycho stayed at Leipzig for the sake of his studies.] It is true that refraction in the winter solstice somewhat disturbed this measurement. Nevertheless, since he neglected parallax in both cases, the fault of refraction was so corrected that it could not exceed one or another minute.

I shall now demonstrate this on the anvil, calling his observation back into examination. He found the Sun's maximum altitude in the summer solstice at $62^\circ 11'$, its minimum in the winter at $15^\circ 15'$. Half the difference of these yields the maximum obliquity of the ecliptic at $23^\circ 28'$. Added to the lowest elevation, or

subtracted from the highest, this gives the altitude of the equator at that place, $38^{\circ}43'$. The complement of this to a quadrant is the elevation of the pole itself, $51^{\circ}17'$. This indeed is how he, neglecting both parallax and refraction, established it.

But we, setting our limits a little differently, will assume at least the maximum altitude, which was free of any tincture of refraction, and to it we will add the Sun's parallax, which was $1\frac{3}{4}'$, so that the Sun's truest altitude in the summer solstice at Leipzig may be $62^{\circ}12\frac{3}{4}'$. If from this we subtract the truer maximum declination found by us, $23^{\circ}31\frac{1}{2}'$, the equinoctial altitude of that place comes out as $38^{\circ}41'$, and its complement gives the exact elevation of the Leipzig pole, $51^{\circ}19'$. This exceeds Homelius's reckoning by $2'$ only, and so it stands more correctly. Accordingly the Wittenberg [pole], by an addition of $2'$, comes out more precisely defined as $51^{\circ}47'$. And even so it does not quite reach the value borrowed from Reinhold's [Reinhold] observation.

But if we bring into consideration the minimum altitude observed there by Homelius, in the same manner — yet first correcting it by refraction, which adds $7\frac{1}{2}'$, and by the parallax, which was $3'$ — so that the more accurate value may be $15^{\circ}19\frac{1}{2}'$; and if to this we add the maximum obliquity of the ecliptic diligently found by us, $23^{\circ}31\frac{1}{2}'$ — then the altitude of the equator will come out as $38^{\circ}41'$, exactly the same as we found before from the summer solstice, when the Sun was free of refraction. Therefore, by the complement, the same elevation of the pole, $51^{\circ}19'$, results — which is what we set out to find. Now the refraction and parallaxes I have spoken of can be sought from their proper canons set forth in Chapter 1 of this book.

And from this single Homelian observation, examined in both directions, it is sufficiently clear that the solar refractions we have established — and likewise the maximum declination (I will say nothing of the parallaxes, which in themselves are not hard to know) — are in every respect correct.

There is therefore no doubt that the elevation of the Wittenberg pole has been so constituted and limited by us with the utmost exactness, and that it stands more correctly than that of anyone else. Nor can the authority of Reinhold or of any other prevail against it here; for in these matters the contest is decided not by authorities but by careful experiment.

Erasmus Reinholdus [Erasmus Reinhold] was indeed an outstanding astronomer, and in this art deservedly eminent — as much as any other of our age — but he himself was chiefly occupied with the demonstrations and the calculation of

numbers, which he carried out most faithfully. To observations, on the other hand, which he merely borrowed from Copernicus [Copernicus], he gave as little attention as possible, nor had he, through any long-continued practice, gained acquaintance with the mechanical work of carrying out astronomical exercises in due form. This was sufficiently shown by that single instrument which he had had constructed — namely a quadrant made of a wooden board, which, though it attained a moderate size, nevertheless had neither subdivisions nor pinnules arranged with sufficient subtlety. I pass over the fact that, being put together from material highly liable to atmospheric change, it could in no way reliably furnish certainty of observation. For when I myself was once present at Wittenberg, I inspected this very quadrant (I am not speaking of things unknown to me), and I was indeed astonished that so great a cultivator of astronomy should have been equipped with no other instruments for measuring the appearances of the heavenly bodies. But, as I said, by a certain deliberate plan of his own he devoted his labor not to observations but rather to the computation of the celestial motions. It is therefore no wonder that he — together with Crucigerus [Crucigerus], who professed theology rather than astronomy — should have deviated from the true altitude of the pole by about a sixth part of a degree. For even great Homer sometimes nods.

I am well aware that the distinguished elder Peucerus [Caspar Peucer], whom I have mentioned before, recorded in the learned little book he wrote on the distances of places that at Wittenberg the equinoctial shadow was longer than the gnomon by a little more than $\frac{1}{4}$ — so that the ratio of the shadow to the gnomon was nearly as 19 to 15; and that, taking the gnomon as 60 parts, the shadow of the same parts is $76^{\circ}43'$ [$76/43$]. From this is gathered an elevation of the pole of $51^{\circ}58'$. This seems to confirm Reinhold's observation — indeed, to make it greater still by four more minutes — whereas by our reasoning it ought rather to be smaller.

But those who deal with gnomonics know well enough how easily a miscalculation arises in such a practice; and Peucerus too is not unaware of it. For the extremity of the shadow is not discerned exactly enough, and unless the gnomon is exceedingly tall, and the horizontal plane on which it stands perpendicularly is leveled true to the mark — both of which are managed with difficulty and not without error — the oil and the labor are lost. And it was chiefly for this reason, there is no doubt, that the most ancient Egyptians and other peoples, being more intensely devoted to this science, erected those most lofty pyramids at vast expense and labor, so that by that very great height any fault that

might be introduced from the plane being less than level, or from the extremity of the shadow not being perceptible precisely enough, might be compensated. (They may also have had other uses in the lower chambers — uses of those same pyramids that it is not relevant to discuss here.)

I say nothing now of the fact that it was not the altitude of the Sun's center, which would be required, but at least that of the upper limb, that is found in this way. This surely, in Peucerus's investigation, would have increased the elevation of the pole still further by about a quarter of a degree — that is, if he examined it with a gnomon fixed on a horizontal plane. But if he observed it with a gnomon set at right angles on a vertical plane, the opposite happens: for then the altitude of the pole is so diminished, as if it became greater by about a quarter of a degree, and thus it would agree very nearly with the value we have extricated.

There is this further point: that around the equinoxes, when the Sun's declination changes much from one day to the next, he set up this consideration, which on that account is not free of ambiguity, since the Sun's motion is not precisely enough established. For even in the Prutenic Canons [Prutenic Tables], constructed by his teacher Reinhold from Copernican foundations, the Sun, near the vernal equinox, eludes the tabulated numbers by its true celestial motion by at least half a degree. About the solstices, therefore, especially the summer one, when any error in the Sun's longitude alters its declination imperceptibly, these matters would be more safely ascertained.

I have recounted these things at somewhat greater length on account of the Wittenberg pole-elevation, which had to be sorted out, because the parallax of this Star, which must be drawn from their observations — and in which lies the very chief hinge of the matter — is investigated in vain unless the elevation of the pole has first been ascertained exactly to the mark.

Nor can I sufficiently wonder why the Wittenbergers, while observing the New Star in both meridian positions, did not by one and the same labor, through the same instrument, measure in like fashion some of the circumpolar fixed stars — especially the more distinguished stars of Cassiopeia [Cassiopeia], neighbors of the New Star. For had they not neglected this, they would surely have found that this New Star, no otherwise than the other stars of the Eighth Sphere that do not pass below the horizon, revolved about the pole at the same elevated, and at the same lower, position — so that, the same pole-altitude being presupposed, they would have found the same difference in these stars as in both meridian positions of the New Star. And thus they would have charged it with the same parallax as the New Star's — and would have wronged the ancients as much as

the New Star alike. And so, the whole matter being reduced to absurdity, they would themselves, without hesitation, have caught the fact that no sure trust is to be placed in their instruments and observations. Or else they would surely have explored another pole-altitude from the fixed stars, observed diligently both in the higher and in the lower position — one such as the assumption of the foregoing required, provided that in the instrument and in the manner of collimation [collimatio] no fault lay hidden.

Therefore, applying this truer Wittenberg pole-altitude, which is greater by scarcely one minute, $51^{\circ}47'$, and subtracting it from the maximum altitude of the Star there observed,

it gives its distance from the pole when it was at its highest, near the vertex, $28^{\circ}9'$ [28/9]. And from this, in turn, subtracting the minimum altitude of the Star, $23^{\circ}33'$, gives its distance from the pole when it was turning below this, in the lower descent, $28^{\circ}14'$ [28/14] — which differs from the one found above by $5'$. And only so much parallax would be gathered together out of these very Wittenberg observations. But if we subtract the highest from the lowest, that lowest would scarcely be greater than $4'$. In no way, therefore, from the Wittenberg observation — if a more correct disposition of the pole is applied — will a parallax of $19'$ be elicited; that value, however, if rightly separated out (which is omitted by them), would in the lower position not quite equal $17'$; whereas with respect to the higher it would reach about three. But now, according to our correction of their observations, the same parallax in the lower position would, as I said, be at most $4'$ nearly, in the higher $1'$. And if by $2\frac{1}{2}'$ only we should render the pole-altitude lower, no parallax of the Star would issue at all from these Wittenberg observations. But who would dare to interpose confidence on the score of two or three minutes, when instruments of observation are set up with less than exact precision? Whether, then, in the pole-altitude there still abound a minute and a third, or whether the altitudes of the New Star ascertained by them have fallen short a very little, above and below in both cases (as is more likely) — a thing that could easily come about, by a slight defect of the plumb-line, or of the pinnules, or of the diopters not adapted in due fashion, since in itself this difference is not very perceptible — it is surely beyond controversy that there was no parallax at all belonging to this Star, as we have abundantly demonstrated in Chapter 6. And therefore, in these few minutes, by whatever error they may finally have crept in, it necessarily follows that the fault is there.

Wherefore Wolfgang [Wolfgang Schuler] labors in vain in distinguishing the place of the Star as seen, when truly in both meridian positions, since he

admitted no diversity at all — even granting that not even thus did he rightly attain its longitude, even when, in the lower position, he enlarges it most. He establishes this [longitude] at least at $6^{\circ}25'$ in Taurus [6.6./25. 8], where they still fall short by $29'$ of the exact longitude he had. So, making the latitude there $54^{\circ}16'$, he increases it beyond half a degree more than is right; whereas in placing the Star at its highest, as regards longitude he fell short by $54'$, in latitude he committed an excess of $18'$.

But as for his saying that the place which was near the vertex is the truer one, on the ground that it then lacked parallax — that cannot stand on its own footing. For if the total sum of the parallax was $19'$, then in the remoteness from the vertex of 10° it was not entirely nothing, but, as we have said, nearly three minutes. Yet since this is exceedingly small, he passed it over without great loss, and nonetheless made the place of the Star most deviant at that point. It is therefore apparent how uncertain and erroneous was the Wittenbergers' attention to be devoted to investigating the very longitude and latitude of the New Star — however much these may lie more readily open to observation. How much less trust

would deserve to be trusted in determining the parallax — a task that called for more difficult turns of reasoning and a more subtle inquiry?

Schuler [Wolfgang Schuler] is quite right, however, when he infers that, with a parallax of $19'$ admitted, this star far exceeded the lunar sphere. For it would have nearly reached the solar sphere if its total parallax had been five minutes, the value we elicited rather more competently from their own recorded altitudes. Yet even this is in truth too large: for since the star in fact had no parallax at all, it was raised not only beyond the orbs of the Moon and the Sun, but above all the planets.

The Most Illustrious Prince [the Landgrave, Wilhelm IV of Hesse-Kassel] came much closer to the absence of parallax, placing the star at the very top — at most $3'$ [M.3]. Nor are Wolfgang's arguments, by which he prefers the instruments of the Wittenbergers and their observations to those of the Landgrave, valid enough. For the Most Illustrious Prince too measured this star repeatedly with his own eyes, and with such care and attentiveness that, on one occasion when he was applying himself to its meridian altitude — which is somewhat hard to take — and some of his servants came up and reported to him that a part of the house had caught fire, blazing up from a sudden flare of the kitchen-fire [Vulcan], he was not in the least disturbed by this and judged the fire to be of no great danger. Instead, intent on the accurate observation, he carried it through without

interruption — as he himself related to me in person. And it is certain that His Highness was far longer and more frequently engaged in celestial observations, and more accustomed to them, than the Wittenbergers, who were in the habit of teaching astronomy from books rather than from the heavens themselves.

We cannot indeed deny that the larger the instruments are, the more reliable too are the observations carried out with them. And yet we took the greatest care over this very thing for one reason above all — though without neglecting the other requisites. For more matters are necessary here than mere size alone. There must be solidity of material, yielding nothing to changes in the air; neatness of construction; fineness of the divisions; proper fitting of the sights [pinnacidiorum] and of the plumb-lines [perpendiculi]; firm supports; appropriate placement; suitable and obliging handling; accurate sighting [collimatio] and counting; and a great many things of this kind besides. Scarcely all of these, however, can be met by a wooden instrument, of whatever size, or at least it cannot long remain sound and intact. I therefore judge that an instrument made of solid metallic material is by far to be preferred, even if it is somewhat smaller. For it also admits a more exact discrimination of the fine divisions, and supplies everything else that conduces to this end more readily and more reliably.

Such too was the Landgrave's instrument, so that there is no doubt that the observations made on this star by means of it did not stray at all beyond those three minutes at the most. There was also that quadrant of the Wittenbergers, which they had kept ever since Reinhold's [Erasmus Reinhold] time, no other having been built in the interim — which was surely a sign of excessive neglect in so renowned an academy,

one that has earned its name above the rest precisely by the propagation of mathematics. By now that quadrant was nearly obsolete from sheer age, so that, apart from Reinhold's authority alone, it could put forward nothing to vouch for its reliability — only that he had once used it. But how little that amounts to, diligent observers of the stars well know. Indeed, even instruments built of solid metal sometimes contract some fault from long use. On this very account Ptolemy too complained, not unjustly, about those Alexandrian armillae — let alone our granting an unalterable steadiness, and a soundness lasting many years (if indeed it was ever there at all), to wooden material. And so the Wittenbergers themselves, when they noticed that their observations were so discordant from those of the Prince himself and from the more select ones of certain others, and would not admit so large a parallax for the star as they had supposed at the

outset, tacitly distrusted their own instrument and observations, and had another one made — a parallactic instrument [Parallaticum], the very one Wolfgang here mentions — much larger still. And although this one too was of wood, and did not have everything required suitably to hand, nevertheless by its very size it in some measure excused itself, if any small fault lurked in it.

In vain, then, does Wolfgang prefer the Wittenbergers' wooden quadrant — at least on the grounds that it was larger — to the Landgrave's brass [Orichalceo] one, forgetting the old saying: *Excellence does not lie everywhere in quantity, but in quality*.

And although in this place Wolfgang does not mention what he afterwards discovered more accurately by means of these very rules — for the final touches had perhaps not yet been put to them — nevertheless he afterwards confessed to me, not unwillingly, while I was passing through Wittenberg, when he was showing me this very instrument, that by its help the parallax was either altogether none, or scarcely reached one minute or another; about which precision, however, he could establish nothing for certain, since it nearly escaped the senses themselves. He praised highly too at that time that most distinguished mathematician Johannes Praetorius [Johannes Praetorius] for the accurate industry and effort he had devoted, by means of this very instrument, to sighting the star. But I myself, besides the instability of the material, found a great deal wanting in its arrangement, balance, the fitting of the sights, the subdivision of the parts — to pass over the rest — and I pointed these out to Wolfgang in person. He, however, tried to excuse the imperfection of the work by the lack of funds.

For I too possess an instrument of this kind, a parallactic one, entirely fitted out with brass, which rests besides upon a very large horizon, twenty feet in diameter, that can be rotated, and matches the largest figure of the table of sines [tabulae sinuum] to five places of figures with its own fine subdivision — yet even so, when it comes to investigating altitudes, I scarcely trust it to within one or another minute, even though everything else I could have wished for in it is provided. The reasons for this I shall disclose in their proper place, when, with God's favor [fauxente Numine], I come to treat expressly of the mechanical part of astronomy.

When he passes to the other question — to set out what this star actually is, and in what place it is set — he will easily make good that it was not one of the number of the planets, nor any of the fixed stars coeval with the world. But that it was a meteor [Meteoron], indeed a comet, is by no means to be approved. For I do not believe that it wished to mingle meteors with the heaven; granted that it

makes comets meteoric, since these — whether he or anyone else thinks otherwise — are entirely celestial.

That elementary exhalations do not enter the ethereal regions, and that no ascents and descents of vapors occur up there, we too will readily concede to him. But that the heaven has solid orbs neither Scripture nor true philosophy will approve. The interpretation of the Greeks, who call the heaven *firmamentum* and στερέωμα [Greek: stereōma, "firmament," literally "what is made firm or solid"], does little to help here; indeed, it squares less well with the Hebrew text, where *Rachia* [רקיע, raqia] is found, which properly means "an expanse" — for which Castalio [Sebastian Castellio] not ineptly renders "Liquid." Moreover there are many other passages of sacred Scripture to the contrary, which jointly establish the heaven to be something most liquid and most tenuous; but a more fitting occasion for speaking of these will be given elsewhere.

That the ether itself undergoes no change, so long as it has pleased the supreme Maker to preserve it in the same state — the experience of the whole age of the world testifying to it — anyone will readily take for granted. Yet that it should now and then take on certain new bodies, themselves subject to that same change, no more follows than it follows from the Earth and the seas lasting perpetually that new monsters of a sort cannot be admitted to be brought forth — soon, indeed, to vanish again.

He acts prudently in being unwilling to introduce novelties into well-established disciplines. But it ought first to have been proved that those disciplines themselves were built well and upon solid principles, as he claims. For if the axioms of Aristotelian physics, which are held authentic everywhere in the schools, stood firm beyond all doubt, then surely experience would never display anything contrary to them. Is it then fitting to approve the inveterate, though false, rather than the true, however novel, and to restore the false to its place? But so it has seemed good to the world — that men embrace not so much what can stand firm in the very truth of the matter as what is commonly held for true.

He alleges in his own favor the political custom of the Locrians, which suffered no change of the laws. But what is this but to say: as though, in matters of religion and the commonwealth, most things did not strike deep roots through long custom which, more truly understood with time, ought rather to be amended? Or is it fitting to approve and confirm one thing not everywhere rightly done by another equally unbecoming example? There are indeed certain innovations that are dangerous, but not all of them on that account turn out unhappily. On the

contrary, they open a door toward the deeper sanctuaries of truth — the one direction in which we must press.

Finally, that he may discover some middle way of somehow reconciling the Aristotelian philosophy with the experience that contradicts it, he says the present phenomenon

is to be counted among comets — not the common kind, but those which, from a viscous and sluggish matter, under an unlucky position of the stars, are brought forth within the elementary region. For he does not hesitate to assert that the ordinary comets familiar in the sublunary air — indulging too much in the Aristotelian opinions — dwell there, and that this has been established many times over by the diligent observations of skilled men. But I, for my part, have found no experiments of this kind on which one might safely rely, in all I have come to know up to now; indeed, in five comets, with my own eyes and with instruments and demonstrations that are anything but deceptive, I have found the plain contrary. The following volumes [Tomi] will treat this more fully, and will persuade the intelligent, without any just contradiction, that the case is so.

That he calls this star an unusual and prodigious thing, and a peculiar work of God, likening it to those which the sacred Books testify were once miraculously beheld from heaven, is set forth by him not, indeed, without plausibility and probable reason. But as for his striving to retain the received doctrine concerning comets in the schools, lest the rightly handed-down disciplines be lightly overthrown, this is to say no more than that, although taught by experience, we are not permitted to say the matter could be otherwise; rather, that we should not retract what we have hitherto believed, lest we be charged with long-standing ignorance, and lest, by admitting it, we be accused of fickleness. And yet this argument has nourished and cloaked many errors — not only in philosophy, but also in matters that regard eternity — for a long time and to a great extent.

He then makes mention of that comet of which Proclus [Proclus] speaks. But although all the particulars reported about it by him or his interpreters are not credible, it is nevertheless believable that Proclus, so eminent a mathematician, declared a comet to have been seen above Jupiter not without good reason. For so great a frivolity is not lightly to be imputed to so distinguished an author — just as I have warned of these things before too.

Finally he concludes that certain rare instances of this sort, which sometimes happen contrary to the Rule, are not to be adduced as evidence by which the divinely demonstrated disciplines might be overthrown. That is to say, that what

has been divinely disclosed should not be overthrown by what a heathen, imbued with no special inspiration of God — namely Aristotle — has taught us to prattle about all these years.

That the arts are gifts of God, no wise man can deny; and that certain things in them should become known to some who are endowed with the natural light alone is not unfitting. Nevertheless I am of the opinion that, to believe these heathen philosophers to have so swallowed up everything in the arts that nothing remains (unless it be chewed over again from their mouths) for those who have been more deeply illuminated by the divine Scriptures, and who have a knowledge of God — if not solid, yet much fuller than these men's — and a truer way of inquiry: that, I say, is not merely absurd, but impious.

Nor are instances of ethereal comets so rare as Schuler [Wolfgang Schuler] supposed. That rarity which he alleges is rather our own slowness, and our want of diligence in scrutinizing the works of God. If all comets, as

all the stars that have ever shone over the course of so many centuries—had been examined with the proper care and precision, with instruments, and had all been duly weighed by geometrical method, then he would have granted that there is nothing unusual in the fact that they exist in the heavens themselves, and that they are not merely rare but unprecedented; rather than conceding that they burn beneath the Moon, in the elementary air, like some sort of lamp.

For our part, so far as God grants, we will not fail to make known to posterity, within the measure of our ability, what experience itself attests in these matters. Nor do we think these things to be scorned merely because they are new—provided only that they are proved truer than the earlier views.

To the other question, concerning the *significations* of this Star, Wolfgang [Schuler] gave no answer at all, and in this he acted prudently. For his prediction surpassed by many leagues the very position of the Star, which it was so difficult to ascertain, and it remains wrapped in more obscurities, which it was better to leave untouched.

I shall add no more of Wolfgang's responses and resolutions to the question proposed. With these matters, I think, sufficiently examined, let me proceed further.

But since we have come to mention that most distinguished mathematician Johann Praetorius—who at that time, when the Wittenberg observations were first being made with the quadrant and afterward repeated with the parallaxic

instrument, was on hand—let us next consider what he afterward concluded about this Star and committed to writing.

D. IOHANNES PRAETORIVS IOACHIMICVS

The excellent mathematician Johann Praetorius [Johannes Praetorius] published no separate treatise specifically on this Star. At that time he was professor of these sciences at Wittenberg, but he now teaches the same subjects in the academy at Altdorf [Schola Altorphiana], founded by the generosity of the people of Nuremberg. In a certain work, however, on the appearance of the great comet of the year 1577—where he enumerates all the comets previously seen that he could gather together from one source or another—he at last appends a brief description of this Star as well. Let us therefore now hear what he set forth about it there, and afterward weigh it. His own words, taken from the said treatise and brought in here, run as follows:

In the year 1572 a certain heavenly body appeared (for so it was usually called) which stirred up the most divergent opinions among astrologers and philosophers. Some maintained that it was a fixed star grown brighter in its light; others, a new creature of God; others, a comet; others again, something intermediate between a comet and a star. But the passage of time has in part removed the dispute over these views. For since it has utterly vanished, while the number of the stars has not been diminished, it turns out consistent that it was a meteor [Meteoron], whether formed from the common material of comets or from some purer

mass. We are certainly well taught that the doctrine of meteorology is not whole and complete in all its parts. For none of the astronomers, I think, denies that its proper seat lies within the orbs of the planets—the region of the world that they call the *ethereal* region. Since in earlier times some, following the opinion of Pythagoras [Pythagoras], the Stoics, and others, asserted that this could be so, they were sharply refuted by others. Let us also observe that the shapes or forms of meteors can be most diverse, and are not confined within fixed limits. It can also happen that the appearance of comets, and likewise of other meteors, comes at times to be at variance with the customary observation of the ancients; and we can be further warned, in many other matters too, even hereafter, of what bears on the enlargement of the ancients' doctrine. Indeed, this heavenly body seems to me, among other things, to confirm the opinion of Jean Pena [Jean Pena]: who, having rejected the discrepancy of the regions of the air, and likewise the sphere of fire, holds that the air is continuous and, without any diversity of material, extends from us all the way up to the stars. On that opinion, however, I wish for the present to settle nothing.*

Now to return to the said heavenly body: it was established within the figure of Cassiopeia [Cassiopeia], together with three of its own stars—the ones that are, in order, the second, fourth, and twelfth—forming a kind of rhombus or trapezium. I see that most writers have used the term "rhomboid," but, in my opinion, less aptly, since the opposite sides of that figure were by no means seen to be equal. It adhered very nearly to the colure of the equinoxes, so that its right ascension differed scarcely by one whole degree from the equator. Its longitude was reckoned at the seventh degree of Taurus [septimum Gradum Tauri]. Its latitude was 54° North [P.54. Sept.]; its declination from the equator, 62° [62. G.].

Many things deserving of wonder came together in it. (I) Its form was wholly like that of a fixed star, without any tail or surrounding mist. (II) Its color was bright, and in the earlier days it rivaled the fixed stars by its scintillation. In its very brilliance it was greater or brighter than Jupiter, yet it readily yielded to Venus in magnitude. And when it had appeared for about two months, it began to grow reddish, so that it even surpassed the fiery glow of Mars; but afterward it became paler again. (III) This body had no motion at all, except that which it always shares in common with the fixed stars; and the place it first occupied it ever afterward retained. (IIII) Its distance from the Earth was so great that it could in no way be perceived—except that it was found to be situated either within the orbs of the planets or above them. This has been confirmed by the observations of the craftsmen, and those who were the most outstanding and most diligent of all in this kind of work affirm that it was wholly free of any parallax. For that reason no certain seat could be assigned to it. For although even Saturn lacks all diversity of aspect, nevertheless from its own proper motion, and from its other accidents, its distance could be defined; but such aids were utterly lacking in the case of this body. (V) Finally, its duration was unusual: it began to be seen in the month of November—somewhat earlier, according to some, but as I observed it at Wittenberg, on the 16th—and it lasted fourteen months.

What followed upon that heavenly body is known to all; and I do not think that its effect has yet ceased, or that it will cease so soon. Some astrologers are accustomed to assign a single year of effect for each month of its duration. Who knows whether this heavenly body too may not extend its powers to the fourteenth year? The years are reckoned from the deliverance of the Israelites out of the Egyptian captivity down to the destruction of the city and the nation in the year 1582; and there have been those who judged, by conjectural reasoning, that this reckoning of the years of Christ would be fatal to the world: this period, accordingly, we see to be contained within the foresaid span. I do not now wish to bring forward the prophecies of others that support this reckoning. Yet it is not foreign to a Christian

to admit, along with the warning of the divine word—whose authority is supreme in all the world—the testimonies of Nature as well, which likewise remind us of the presence and the wrath of God, so that we may be the more ready and prompt, as men who at every moment must render to God an account of their faith and their actions.

Thus, then, the most learned Praetorius supposes this Star to have been some meteor, whether composed of the common material of comets or of some purer mass; and yet he nonetheless admits that its seat was plainly ethereal, above the elementary region. He seems to associate the meteors—and these stars too—with the heaven, which has hitherto been believed by them to be exempt from such things. But if it deserves a place there, then there will surely be the very greatest difference between elementary and celestial meteors. Yet there will be no great question about the name, provided the thing itself is established. For my part, I have judged it better to call it a *new star*, since it was most closely like the very stars and had also newly come into being. And that it should cease to exist was fitting to its temporal origin.

He had most truly asserted that the doctrine of meteorology is not in every part complete; indeed, I should rather believe that even the smallest part of it has so far been correctly established. The book of Jean Pena, in which he holds that the whole heaven is nothing other than continuous air, I have not yet seen. Although this view—by which the heaven is supposed to consist of elementary air—is less aptly held than it might be (as may be seen from the volume of *Letters* in which, together with the most learned Prince the Landgrave [Landgrave], the mathematician Christoph Rothmann [Christoph Rothmann] defends this same opinion, on which subject I discuss the matter at length, so that those who wish may examine and judge it): nevertheless this opinion comes much nearer to the inner truth than the Aristotelian one commonly approved, which has filled the heaven with a great many real and imaginary orbs, with no basis in fact.

Praetorius, moreover, seems to want to assert that this speculation of Jean Pena is confirmed by this New Star. He therefore supposes that this aerial heaven, having risen on high out of some elementary material, penetrated its depth, pierced its loftiness, and that from this the meteor (as he calls it) was forged. But Pena's imagination, concerning a heaven of air, lends no support here at all. For even if it were so: nevertheless, since this Star surpassed several hundred times over the mass that Earth and the seas together compose—as we showed in Chapter 7 [veluti cap. 7]—surely no exhalations of the Earth or of the sea, even if they could enter the heaven (which in itself cannot be granted), would suffice to form so great a body. I pass over the fact that they could not have furnished it with that

stability of so long-enduring a form, to be ranked equal with a genuine star—and many other things more fully indicated elsewhere, which it would be tedious to repeat.

He well designates the place of this body, though in a broader fashion, and he recounts the things worthy of wonder in it, exactly as they truly stood. And what he reports last bears most upon my point: namely, that this Star was utterly destitute of any parallax.

From this it is plain that, while he was still residing at Wittenberg, he investigated this imperceptibility of parallax by means of that parallactic instrument which they afterward erected there; and that he then, beyond all doubt, struck the mark he aimed at more accurately than the Wittenbergers had before—he being involved in no small share of the work between.

But that I was unable to assign a certain seat to it for the reason that it was free of all parallax, as he infers—this does not seem to me necessarily to follow. On the contrary, it rather turns out consistent, on that very ground, to exalt it above the orbs of all the planets, into the highest sphere of the fixed stars. For even the highest of all, Saturn, suffers a slight parallax, which near the horizon amounts to a third part of a minute. If, therefore, this Star had absolutely none (as Praetorius rightly maintains), then it surely was above Saturn; and so it was among the rest of the fixed stars, which it also represented admirably by its continual fixity and its scintillation.

But as for the fact that he supposes Saturn to lack all diversity of aspect: he holds this either from the Ptolemaic hypotheses, where the matter is more correctly placed, or because he reckons that minute parallax—which does not exceed a third part of a scruple—to be nothing on account of its smallness, as it is indeed almost imperceptible. We, however, have already set forth before, in Chapter 6 [cap. 6], the reasons—sufficient, as I hope—by which this Star deserves rightly to be ranked among the fixed stars; and it would be superfluous to repeat them.

He sets its duration at 14 months, whereas it rather completed a full 16. But this could easily happen, since on the matter of the time of its persistence there is a discrepancy, according to the differing keenness of those observing it. For after the beginning of the year 1573 this Star appeared so faint that many supposed it had vanished at the end of January or in February, although in March it could still be discerned to some degree. So too the comet of the year 1577 [Cometa Anni 1577]—of which we shall treat in the following book—was believed, in the estimation of Praetorius and of many others, to have ceased about the 10th day of

January in the year 1578; yet on the 26th day of the same month it was observed by us still showing some faint trace. But these matters, as regards the various and differing limits of its duration, are of no great moment.

I shall add nothing further to what the most learned Praetorius set forth there about this Star; for he himself covered so wide a subject in brief compass. Nor shall I touch upon the things he adds, in a few words, about its effects, and joins to the preceding matters—since I would say something, when by themselves they are at most conjectural and scarcely deserve any extended reply. This much at least I subjoin: the portents of his Star had hardly so much as begun—let alone expired within the fourteenth year, in proportion to the months he supposed it to have lasted. What I think on this matter I will set out more fully in the conclusion of this book.

And so now, having left the Altdorf school of the Nuremberg men and moved on to Tübingen, we shall examine what reply Philipp Apian wrote back to the Illustrious Landgrave Wilhelm [Wilhelm IV, Landgrave of Hesse], who had raised questions with him about this star. For some time ago we already presented the replies of the same Illustrious Prince, together with those of Peucer [Caspar Peucer] and of the Wittenberg men, all of which had never gone to press. And here too I am pleased to subject to scrutiny a letter of Apian's, written to the same Prince about this matter and, so far as I know, not published until now. My aim is that everything relating to this star which was proposed and done by this most praiseworthy Prince — so far as it has come to my knowledge — should be gathered, as it were, into a single bundle (with only Praetorius [Johannes Praetorius], who was also then residing at Wittenberg and attending to the star, interposed), and that these accounts should follow one upon another; afterward I shall turn to other authors.

D. PHILIPPVS APPIANVS.

Although that most learned man Philipp Apian published nothing about this star — the son of the elder, celebrated Petrus Apianus [Peter Apian], a man of high merit in matters astronomical, and in cultivating these disciplines no degenerate follower of his father (the man with whom, I recall, I became acquainted many years ago, when I was passing through Ingolstadt, a little before he moved away from there) — nevertheless his reply, written in his own hand to certain letters of the Illustrious Prince Wilhelm, Landgrave of Hesse, did at length come into my hands. The Prince had proposed to him certain matters about this star, so that he might write back his judgment on each point; and it came to me through the efforts of my old friend Hieronymus Wolf [Hieronymus Wolf] (of blessed

memory), at the time I was staying at Augsburg. The greater part of these documents, to be sure, had been written out in German. But I am glad to present them here turned into Latin, since they may perhaps not otherwise be readily at hand, and so that at the same time it may afford a starting point for the matters we have to investigate concerning these questions. As for an exemplar of the Illustrious Prince's letter sent ahead to the said Apian, I have not had the chance to see it; otherwise I would not have omitted to add this too. But what questions he raised there is sufficiently clear from Apian's reply alone, which I now append.

A copy of the letter written out for the most Illustrious Prince Wilhelm, Landgrave of Hesse, by D. Philipp Apian, in which his judgment about this star is declared.

Most gracious Lord, I received your Highness's letter, in which you require that my opinion and judgment about the New Star — seen for some time now toward the north and the Arctic Pole — be set out for you, a few days before I received them, in detail, so that certain particular questions might be graciously explained. For which reason, your Highness, I shall not modestly conceal that I observed the aforesaid star, or comet, even six weeks beforehand, and that I diligently observed it on individual days right up to that same time; but, owing to the weakness of my body, for four straight weeks I was prevented from preparing myself as I should — so that I might note its position and the other required particulars. What I shall modestly indicate to your Highness, together with the other matters pertaining here, I humbly ask that your Highness be willing to receive in a kindly spirit.

As far as your Highness's first question is concerned — whether this star is new or not — I cannot answer your Highness otherwise than that it is new, never before seen in that place in the sky. For in the asterism of the figure of Cassiopeia (alongside which the star itself has hitherto appeared) the larger stars noted by the ancient astronomers and seen up to now are of the third magnitude at most; but this new star not only exceeds in its size the greatest stars, which we call those of the first magnitude — among whose number are Sirius [Canis Syrius] and the other fixed stars — or at the very least is seen to be equal to it. This new star is set among the three greatest and most notable stars of Cassiopeia, forming a figure which the geometer calls a rhombus, or more correctly a trapezium; it stands plainly at the western extremity of the Milky Way toward the north, so that it has reached the Circle (whose name is the Equinoctial Colure [Colurus Aequinoctiorum]).

With respect to the astronomical arrangement of the signs of the Zodiac, its place falls in the sixth degree of Taurus [♉] with a few minutes more, with a latitude from the ecliptic of 53 degrees and some minutes. With respect to the eighth sphere, that is, the constellations of the signs, it is found in the middle of Aquarius [♒].

Secondly, your Highness wishes to know how long this star, or comet, has appeared. This I cannot determine with sufficient strictness for your Highness. I first noticed it around the 10th of November. But at that time it was not attended to as it should have been. Without doubt, however, it had presented itself to view some days before, just as it did to me too; and it has been reported [that it appeared] earlier. In my own judgment, though, it did not shine before the beginning of November, or at the latest the 20th of October.

But before I disclose the reasons for my opinion as to why I hold that it had its first beginnings around this time, this autumn, your Highness should know that experience teaches that no comet has been seen except where eclipses of the Sun or Moon, or conjunctions of the superior planets — which we call the great conjunctions — have preceded. This is something that Ptolemy too, Albumasar [Abū Ma'shar], and others attest, and it could be proved by many examples, which I omit for brevity's sake. Therefore, if, looking back, we consider the eclipse of the Moon seen on the 25th of June of this year, and also the great conjunction of Saturn [♄] and Mars [♂] which occurred this past 7th of August, and weigh them, the astrological causes of this comet or star present themselves — all of which to recount for your Highness would perhaps be more tedious than welcome. The chief cause, however, was this conjunction of Saturn [♄] and Mars [♂], which occurred in the house of Mars [♂], with Jupiter [♃] set up at the beginning of Taurus [♉] in the second house, opposite [to them], and on the same day beginning to turn retrograde. In which sign or place that comet has hitherto been seen with respect to longitude. The luminaries, together with Mercury [☿], were in the Angle of the West, and the Moon [☾] was in quartile aspect with Saturn, Mars, and Jupiter [♄ ♂ ♃]; Mercury [☿] also had a quartile to Saturn and Mars [♄ ♂]; and several other things besides could be considered here. Configurations of the planets of this evil kind without doubt furnished the cause for this comet. After the Sun, then, by its proper motion, reached the place of the said great conjunction around the 20th of October, and Saturn together with Mercury [♄ ☿] in the same place, joined to the Sun by a partile conjunction, and out of the house of Mars [♂] and the Angle of the East, with the Moon [☾] standing in the 7th degree of Taurus [♉] —

— standing in the western cardine, they looked from the opposite, and Jupiter [♃] was still retrograde and very near it. For my part, I judge — so far as the measure of my talent allows — that this same comet then first came forth and began to appear from the constellation just mentioned. And what no little persuades me is that on those very days that cold set in, especially when the conjunction of Saturn and the Sun [♄ ☉] took place; and the causes of this premature, prolonged, and unheard-of cold were the aforesaid aspects. These things I wished to indicate here briefly. If the time of the first appearance were established with certainty, another and easier reckoning of this could be set up.

To the third question this is my answer: this comet or star did not change the place mentioned, where I first observed it, but remained entirely fixed and motionless up to now, just like another fixed star; and meanwhile no other motion has been observed in it than the one by which it is carried around the Arctic Pole in parallel circles — which, on account of this, is called the diurnal motion, because by day and by night, that is, in 24 hours, it completes one revolution. And since this star is set apart from the Arctic Pole by no more than 28 degrees, it neither rises nor sets nor goes below the horizon, but is seen the whole night round the Pole (just as the Great Bear [Vrsa maior] is too). But whether it will remain so motionless, and for how long, and whether it will change its place and move on from there, future observations will reveal.

Furthermore, as to its magnitude, I can find no particular distinction — although to some it now seems a little smaller. But the fact that it sometimes appears perhaps larger, sometimes indeed smaller, can happen on account of the brightness of the Moon, the variation of the air, and other causes — especially when this star comes back closer to the horizon; and in the morning, just as the other stars, the Sun, and the Moon appear larger when in a lower position, by reason of the exhalations or vapors rising in the air. It can also for these causes sometimes change its color and be seen somewhat more reddish near the horizon.

Moreover, as to whether this star is a meteor [Meteoron], and how it should be named, various opinions have arisen among the learned. But that it is not a fixed star, nor a planet — in my judgment no intelligent person will dispute. And this is my opinion: that this star is nothing other than a certain kind of comet, which up to now has shone without a coma or a beard or tail (as they call it). And several similar ones have been seen before, as the Arabs and other astrologers report; and they call stars of this kind "secondary stars."

Joannes Anglus [John of England (Johannes Anglicus)] writes in several places, and from other astrologers, that the conjunction of Jupiter with Saturn [♄ ♅] makes a star in the manner of the Moon [☾] without a tail. He says that all these things, too, come about through aspect, just as through conjunction, only when they look upon one another centrally. Furthermore, that this comet or secondary star does not exist in the elementary region, but should be counted among the fixed stars, can be gathered from the fact that it is much higher than the Moon [☾] and produces no parallax, nor is any diversity of aspect caused, as the Moon [☾] does. And if it had to be placed beneath the sphere of the Moon [☾], its parallax would far exceed that of the Moon. Add to this also that no motion in it has been detected up to now, but it moves on entirely like a fixed star with the firmament, at least around the poles of the world. And the fact that it appears without a tail, this too I would gladly ascribe in part to its altitude. From the causes here recalled, I judge that this star stands very high, in the ethereal region. But in my saying that this New Star is a comet and is found in the ethereal region, the natural philosophers [Physici] and Aristotelians [Aristotelici] will not agree with me, since [they hold that] nothing can exist or appear above the Moon, which again

perishes, they suppose. And so the question arises, what comets properly are. Afterward, whether they can appear and exist in the ether, may then easily be understood. The natural philosophers teach that a comet is a burning of exhalations heaped up in the highest region of the air.

But it is not now fitting to refute this opinion with many arguments; I say so for this reason only — that on this very point certain astronomers, from optical reasonings, may judge it of no weight at all, but may hand down and demonstrate from a more solid foundation that a comet is a transparent material illuminated [by the Sun]. The opticians, too, bring forward reasons: that a comet is generated by the concourse of the Sun's rays and others breaking and meeting one another, in a certain part of the sky; and this has been detected from the tail of the comet, which is always stretched out in the part turned away from the Sun. And from the observations of certain comets this has been sufficiently demonstrated by my own father [a parente meo], and up to now approved by many other learned men, and in the same way observed and noted. So that, even from these observations alone, it follows that no comet is a burning.

Indeed, also in autumn, [it follows] that they do not consist of their own proper substance, but come to be in the celestial world, and not only in a single orb or heaven, but in several. For the fact that comets have always appeared only in the

elementary region beneath the Moon [☾], and have had their course there, the opticians will by no means concede, since the motion of many comets shows and proves otherwise. For which reason I, for my part, hold this star (which, as said above, must necessarily exist in the ethereal region) to be a comet. Experience too of astronomy teaches that some comets were first seen in the likeness of stars, and afterward seen with a tail; others, by contrast, lost the tail and afterward appeared as it were as stars. And so it is (just as we hinted above) that there are manifold species of comets, of which Pliny [Pliny the Elder] and Ptolemy, from long observation, count up nine. And whether they are thought to have tails among these too, there is also a distinction.

Lastly, since your Highness requires that my judgment, such as it is, about this comet be set out astrologically, to which I would offer myself with all due submission as most ready: nevertheless I will not conceal from your Highness that nothing can yet be predicted about the effect of this comet. For of its effects, or those of other comets, no one ought to say or judge anything in particular before, after a long duration of the apparition, they have all vanished — namely their daily place and motion from beginning to end, likewise color, splendor, magnitude, form, relation to the Sun, ending, and several other circumstances, that is to say the preceding eclipses and the great conjunction of the superior planets, have been diligently disclosed and weighed. Experience nonetheless teaches that comets observed have always been followed by peculiar and sad effects, as may be seen from many historians and from the books and observations of the astrologers. But speaking generally of these things, they portend great drought, very often turbulent winds, earthquakes, great heats of summer and intense cold of winter, the destruction and dearth of crops, the high cost of provisions, famine, great and sudden plague, and other grave diseases besides; war, the death of great and powerful princes, the wonderful changes of kingdoms and states which usually accompany them, and many more of this kind. And the longer they have been seen and the more fixedly they have remained (like the one we are dealing with here), the more vehement and longer-lasting their effects will be, and they usually extend themselves over several following years.

But since this comet or star was excited together with the others by Jupiter [♃], and was made retrograde near it, in respect of the other planets — apart from certain of the chief Great [conjunctions]

the death of one already born, and likewise upheavals in public affairs. Moreover, according to the astrologers, the star of Cassiopeia also foretells

servitude and desolation, along with other things. For my own part, however, just as I said earlier, I do not yet wish to assert anything definite about its effect.

These thoughts of mine I owed it to Your Highness not to omit, having set them down, to the extent that I understand the matter, in humble response to your gracious request. May Your Highness be pleased to receive and interpret these reflections, opinions, and partly conjectures of mine in a kindly spirit. I now commend you, together with your subjects, to the protection of Almighty God for a long and prosperous reign, and once again humbly submit myself to Your Highness. Given at Tübingen, 26 December, in the year 1572.

To Your Highness,

Most humbly,

Philipp Apian [Philipp Apian]

An inquiry into the matters that the foregoing letter of Apian addresses on the more important points.

To the first question of the illustrious Prince, Apian replies very correctly: that this star was indeed dissimilar to the other stars of Cassiopeia in magnitude, and so unlike the stars of the first rank, exceeding them by a great deal. It was even equal to Jupiter, if not in fact greater. Furthermore, the things he reports about its shape (which he compared with the brighter stars of that same constellation) and about its position relative to the Galaxy [Galaxiam] and the equinoctial colure [Colurum aequinoctiorum] are not inappropriate. Yet the place he assigns to it in terms of ecliptic longitude and latitude he marks out far too loosely, even in the whole degrees themselves. But if he had judged that no very precise reckoning of the minutes need be made here, why did he commit an error of nearly a full degree from its true position, both in longitude and in latitude? — as is sufficiently shown by what we brought forward in Chapter 5 [cap. 5] for the exact determination of its place.

Concerning the second question raised, about the time of the star's first appearance, he reasonably shows himself uncertain. He says he first caught sight of it on 10 November. But that he presumes it to have shone from the beginning of November, or even from 20 October, these are wholly empty conjectures, resting on no sure evidence. For the reasons he draws from astrology are not even probable, much less to be accepted. For if eclipses of any kind, or indeed conjunctions of Saturn [♄] and Mars [♂] — which occur every other year — and the similar configurations he piles up, or the heavier ones that more often

happen to fall together, could produce the generation of some new star or comet, then surely nothing would any longer be new: new stars would be appearing in the heavens, [p. 648] or comets shining out to us from there. For something of this sort happens almost every year, and so all novelty, together with our wonder, would be lost.

I am indeed aware that certain astrologers hold the opinion that eclipses and the more conspicuous configurations of the superior planets supply the occasion for the generation of comets. But however many they are, in this matter — as in many other claims they put forward — they offend gravely against the truth, and against experience itself and skill, and they hold out for the contempt of scoffers the very art that, if soberly and skillfully handled, would not deserve such reproach. For in no way did any comet, still less this New Star, take its origin from the various disposition and flux of the other everlasting heavenly bodies. On this matter there is occasion to discuss it more fully elsewhere, when I deal professionally with comets. Indeed, even granting that the commixtures of the planets contribute something here, they are nonetheless far too weak and feeble to bring about the formation of some New Star such as had scarcely been seen in nearly two thousand years before — the formation that Apian traces to astrological causes. For how could an eclipse of the Moon contribute to this — barely four or five at most, in the sign of Pisces [♓] at greatest, declining when in turn the greater eclipses, both of the Sun and of the Moon, happen yearly about six times by reason of the different horizons — without their producing new stars? And how, I ask, could the conjunction of Saturn [♄] and Mars [♂] (which is not in itself reckoned among the great conjunctions, as Apian here thinks, but is rather counted by the astrologers as middling or among the least) occurring about the first decan of Scorpio, bring this about — when that conjunction is by no means one of the rarely-occurring planetary commixtures, but such a one happens necessarily every other year? And here too I cannot sufficiently marvel that Apian was unable to fit to this conjunction not merely the day but even the hour and the minute (for otherwise he could not have set the cusps of the celestial houses, as they call them) — especially since the motion of Mars [♂], as I shall now say, has up to now been so little explored that it is not safe to assign their conjunction within three or four days, by the Alphonsine reckoning [Calculo ... Alphonsino] which he used, nor indeed by the Copernican, even though it is somewhat more exact. How invalid, then, are the things he builds upon this, is readily apparent — just as is the other point too, about the first appearance of the Star drawn from the passage of the Sun through the place of the said conjunction, and the pretext of cold so intense and so prolonged. All of these are of no weight whatever, and contribute nothing toward excusing and accounting for so great a

marvel; so that to treat them at greater length, and to refute them, is not worth the trouble, since they deserve only outright rejection.

The third question — that this Star remained perpetually unmoved, and at least obeyed the universal revolution — he answers truly and competently. But he doubted in vain whether it would remain immovable in the same manner forever, since it never in fact took on any proper motion of its own.

Its magnitude did indeed decrease, though not very perceptibly, around the beginning, in November and December. It is certain, however, that it was successively [p. 649] diminished, just as we indicated this alteration in order in Chapter 3 [cap. 3]. Nor does the light of the Moon, or a change in the air, leave any room for this excuse, since the slight difference that could arise from these was temporary and did not last long. Likewise, what he says — that on account of its approach toward the horizon it changed color — is rightly stated. For if some such thing happened to it accidentally, through vapors gathering at the horizon, it could occur; but in air thoroughly purified it would be imperceptible: for this Star stood on the horizon of Tübingen, where Apian was living at the time, no nearer than 20 degrees [20 Gradū] to the horizon. And indeed, at so great an altitude the Star is so vindicated from the injuries of terrestrial vapors that it is scarcely perceptible, and it takes on nothing whatever foreign from them. He next says that it was variously disputed among the learned whether this Star was a meteor and what name it should be given. On this point, whoever raised any doubt did so without just grounds. For who ever beheld in the sky a meteor most like the genuine stars, so that I should say nothing of its immobility and so great a duration? At last this author pronounces that this Star was a certain peculiar species of comet: from which view some of them held that it was previously seen even without a tail and without rays [crinibus].

This indeed I would by no means concede, and sufficient reasons why it ought not properly to be called a comet have already been brought forward several times, so that it is certain that some comets have at times shone entirely round, without any beard [barbam] — as that one was which we observed in the year 1585 [Anno 1585]. For this happens rather by accident, namely when comets are situated about the opposite point to the Sun, and the rays struck from the Sun — which the common people call a beard or tail — are turned upward and away from us. And this also held for the one I just spoke of. Or else, when they are at too great a distance from the Earth, about the regions of the superior planets (for that comets are generated there too I have no doubt) — then the tail, on account of its thinness and its very great distance from our sight, scarcely meets the eye.

Therefore, although Apian advances certain things about comets, not inappropriately, in the place of proof, nevertheless these and similar matters he applies less properly to excusing the appearances of the New Star. For it possessed very many things wholly alien to the nature and condition of comets — things which we have elsewhere sufficiently enumerated. The astrologers do indeed call comets "second-magnitude stars" [Stellas secundas] — chief among them, and most especially, the authentic Ptolemy [Ptolemaeus]. But that they ever saw anything like this, and that they included a Star of this kind under the heading of comets, cannot from this be proved. Indeed Ptolemy himself, captivated rather by the subtleties — or rather the futilities — of Aristotle [Aristotelis], thought less rightly about the nature and generation of comets, likening them to fiery meteors, and asserting them to be produced from Mars [♂] and Mercury [☿] as the authors of dryness. How far these notions are at variance with the truth of the matter will become clear in the following books.

In vain, therefore, does Apian cite, on his own behalf, the doctrines of the Arabs and of other astrologers, entangled in vanities. Nor do I dwell on the fact that John of England [Iohannes Anglus] reports several times that the conjunction of Saturn [♄] and Jupiter [♃] produces stars that are not tailed, [p. 650] and that partile aspects do the same. For I know how much that is mostly false and empty he has heaped together, out of the futilities of many astrologers, with no discrimination and no rigorous judgment — so much so that in many pages scarcely a single line is to be found that agrees in every way with truth and experience. And let us not seek examples far off: if a great conjunction of Saturn [♄] and Jupiter [♃] produced adventitious stars, whether tailed or without tails, why did the great conjunction of Saturn [♄] and Jupiter [♃] in our own age, in the beginning of Leo [in principio Leonis] — a sign they call fiery and burning — occurring in the year 1563 [Anno 1563], engender nothing of the kind in the years immediately following? And — to say nothing of the other configurations of the heavier planets, both oppositions and quadratures, occurring from that time in the heavens, partile and in manifold ways — these nonetheless produced no stars or comets of the kind. Certainly that greatest conjunction of all, the like of which is not given within eight hundred years, which was celebrated about the end of Pisces [♊], toward the beginning of Aries [♈], in the year 1583 [Anno 1583], with very nearly all the planets concurring, presented to view no stars of this sort, whether tailed or quite round. For neither could that bearded comet which was observed for about three years after the end of the year 1585 [Anni 1585] be referred to it, except by forced reasoning.

And how many comets, I ask, did we behold within the last 12 or 13 years, none of which coincided with any great conjunction, or required similar configurations (as the astrologers suppose)? Yet let us grant them those great combinations of Saturn [♄] and Jupiter [♃], such as occur singly every twenty years, do foretell comets or untailed stars; how then will they account for the origin of this New One from that source — since no great conjunction of these two planets, nor any exact and evident configuration of them, preceded its appearance? For the one that occurred in the year 1553 [Anno 1553] was nine years earlier, and their great opposition, which took place in the year 1573 [Anno 1573] in the month of May, did not precede this Star, but happened after its disappearance — and that opposition was quite platonic, on account of the differing latitude of each. Likewise, neither could the quadrature of Saturn [♄] and Jupiter [♃] in the year 1569 [Anno 1569] contribute anything here, since in itself it was of no great moment. To what end, then, are those things which have no bearing on the matter, and which do not even deserve a place here, brought forward by Apian in the midst of his argument as an excuse for so great a marvel as appeared in the New Star? But, leaving these aside — since they scarcely merit so laborious a refutation — let us rather consider what he adds afterward.

He next pronounces, very correctly, that this New Star did not exist in the Elementary Region [Regione Elementari], since it admitted no diversity of aspect [parallax], to which the Moon is very much subject. And he supports this, not incompetently, from the stability of its place: that it presented itself, like the rest of the fixed stars [Fixarum], in its own revolution. But although he brings forward no observations on which to ground it, this

proves geometrically that the star was wholly without any parallax — which is, indeed, a properly mathematical conclusion. Yet the inferences he draws from mere visual inspection, as I see it, all hold up: he rightly concludes that this star was set very high in the aetherial region, where it had taken up its station. But when he goes on to try to establish, on the same basis, that it had no tail because none was observed, this seems plausible enough, though not yet sufficiently proved. For if any tail had clung to this star, it would surely have shown some trace of those rays from the very beginning, when the star was thrusting itself so conspicuously upon the eye with so large a body. Nor — given that the Sun's light pours past, and the star stood diametrically opposite the Sun — could a tail, had it possessed one, have been any less discernible; for it would not have stretched directly upward, but obliquely to some degree. And since the star's body was so plainly visible, and indeed at its largest, it was quite enough to display any rays it might have had. Moreover, certain comets observed by us were so far removed

from the Earth that their parallaxes were altogether imperceptible; these nonetheless, though not very much so in their head, displayed both the star itself [conspicuous] and tails that insinuated themselves clearly enough upon the eye.

It is quite certain that the common run of natural philosophers and the Aristotelians — who in this would refuse him their assent — will not hesitate to maintain that comets are not aetherial: for this directly contradicts one of their axioms, the one that lays down that the heavenly bodies are not subject to alteration. But whether this is in fact true, granted that it had to be proved by Apian otherwise than has here been done — that needs no flattery, and fears none of the natural philosophers' frivolous quibbles, since the truth remains constant and unconquered, in need of nothing. There is no doubt at all that it is entirely false that comets are compounded out of terrestrial exhalations, as the Peripatetics will have it. As for Apian's claim that this can be refuted by optical reasoning alone, he advances it without supporting argument, since he brings forward no optical demonstrations of the kind to make his point.

That the tail of comets is everywhere turned away from the Sun, that excellent and most distinguished man Peter Apian [Petrus Apianus], his father, established with great care in a number of the comets of his own time; this makes it quite clear that the said tail is no kind of burning flame, as the Aristotelians contend. Otherwise it would always stretch perpetually upward, or at least would be projected toward the parts away from the Sun, not in every direction. So far, then, optical reasonings might serve to confirm some part of the truth. But as for what he supposes is to be inferred from their doctrines — that comets are formed from the meeting of solar and other rays breaking against one another, so that he afterwards does not hesitate to assert that comets consist of no proper substance of their own, and nonetheless (a view not in itself foreign to the truth) are produced within the several spheres of the planets, but are formed in the heavens, as he wishes, from a meeting of rays — that, I say, cannot be demonstrated by optical axioms and the inductions built upon them, without a genuine refraction. And even if this speculation, however absurd in itself, could in any way be applied to this star, I ask, how could it come about that the meeting of the rays

alone should produce a body shining like a genuine star for more than a whole year, fixed in the same place in the heavens — when it is anyway devoid of any essential matter? And further, if such a phase were formed by the meeting of the rays of the fixed stars, why does this not happen more often from a like cause? And finally, if it arose like a torch from the planets, by the conjunction of their

vibrations, how could it stand still so long in one place, while those very planets that produced it are whirled around in perpetual motion? But let such things go: they scarcely deserve a reply. This frivolous opinion seems to have been drawn from Girolamo Cardano [Hieronymus Cardanus], who at the beginning of his books *On Variety* [*De Varietate*] pronounces his judgment about comets in the same incompetent manner.

How far these opinions fall short of the genuine nature and essence of comets, and are wholly alien to their properties, I shall set out — and, having recalled the superfluous opinions of others about the generation of comets, expose their falsity — at the end of the whole work on these accessory phenomena of the heavens. So as not to be over-long here (since the matter cannot be settled in a few words, being entangled with many other things, with windings and circumstances), I judge it more fitting to defer it to that place. Yet what Apian infers and concludes — that this star stood in the aetherial region, as he had also affirmed before — must by no means be denied. But that it should therefore be called a comet I have not conceded.

I admit, indeed, from the accounts of astronomers and natural philosophers (which he brings forward by way of further proof), and attested by our own experience in certain of our observations, that some comets were at first without a tail and acquired one afterwards, while in others the reverse occurred. Still, this diversity has no bearing here. For the reason why a tail is sometimes seen in comets, and sometimes not — well enough known — has by no means been understood by those who have raised this question. For since the tail comes about incidentally from the Sun, depending on the varying disposition and arrangement of the comet's head with respect to the Sun, the tail is either wholly hidden from our sight, or meets it more or less. And this is how it has come about that some have supposed comets did not have this hair, or rather this ejection of solar rays, from the beginning, or else lost it afterwards — when in fact the motion of the comets, in relation to the Sun, absolutely requires it to be so. There is likewise no doubt that comets present manifold appearances; but among these there is not so great a diversity [as] [recte: as] the ancients and certain moderns suppose, in imitation of them. For the variety of outward form that commonly appears has its cause from a source other than is thought, and is something accidental rather than real. However many comets we have observed up to now, and however many were marked out in the heavens by this Apian's father and by other intermediate mathematicians, seemed to differ from one another in nothing as regards their more principal features and their real condition. In certain more particular and incidental matters there was no small dissimilarity;

yet those who consider the thing itself in a universal way will be able to account for this, and reconcile it, without difficulty.

Nor, even if (following Pliny [Plinius]) nine or more species of comets were to be counted, would this star, of which we are now treating, deserve to be ranked with any of them: for — apart from the mere change of magnitude and color, and the fact that it began and ceased to be — it had nothing else in common with them, so far as can be demonstrated from observations.

He passes at last to the astrological question of this star's significance. He deliberately steps over the point that, because all the circumstances bound up with this star throughout its whole duration had not yet been explored, and pronounces only in general terms about its portents, in the way commonly accepted by astrologers and natural philosophers. But all this, as is plain enough of itself, is said far too crudely; nor does he separate this star from ordinary comets — indeed he does not even properly explain the rulings concerning these — and likewise, wavering this way and that on too broad a path, he strays from the strict track of that hidden philosophy more than is right; and to comets appearing from time to time he attributes, with scarcely any fitness — let alone to such a star, which for so many ages had not been noticed — things which might rather derive from some other source than from these, [or] which, if from these, drew their origin whenever they happened to accompany their flashing forth. And so he brings in, unfittingly, as a cause what is no cause. On this account, since I have decided to treat the matter more fully elsewhere, I shall add nothing further. And since it is not my intention to inquire so anxiously into the astrological opinions as well, I refrain from weighing the speculations in Apian's conceptions any further.

THOMAS DIGGESEVS CANTIENSIS ANGLVS. [Thomas Digges, of Kent, Englishman]

Leaving Germany for a little while, let us now cross over into England — at least so far as that excellent and learned man Thomas Digges [Thomas Digges], a man of noble lineage, promises in the very words he has placed by way of title at the head of his little book: namely, that with his other instruments, or mathematical scales, by which he has scaled the most remote theaters of the heavens and explored the courses of all the planets by new and unheard-of methods, he has — with regard to this portentous star shining in the northern region of the world with an unwonted brilliance — flown up to and ascended to its distance, magnitude, and immense situation; and that this stupendous prodigy, displayed

to the dwellers on Earth, may be known most clearly, so far as concerns the new star and the rest of his promises. Yet however learned and ingenious this writing is, and however much it displays an excellent mastery of mathematics — nonetheless, if one may tell the truth, in its inmost recesses it delivers the very least of what it promises at first approach and in so magnificent and showy a title. For it does not even explain in every way, as it ought, the phenomena of the new star itself — the chief object of consideration — let alone unfold the courses of all the planets in a new manner. He seems to have applied himself to that — though with the utmost diligence and no mean skill — chiefly in order to set out in a general way certain problems serving the resolution [enucleatio] of parallaxes, and demonstrations of the same. He has

also some things, recorded with shrewd diligence, which he brings forward concerning the limitation and correction of the astronomical radius [radius astronomicus]. But here almost everything is dogmatic, and Digges sets forth very few observations of the proposed star, much less applies them to use, in the way they ought to be applied.

But now let us inspect the little book itself in order, and on each of its contents — where there is occasion — let us freely append our own opinion, with no intent to disparage the author (whom I otherwise esteem), but only to bring the deeper truth out into the open.

At the outset he presents the figure of Cassiopeia with its stars, and the position of this new star with respect to them: here, in the arrangement and numbering of the stars, he follows the customary reckoning of Copernicus's tablet [Abacus Copernicus] and others; yet in some places this departs from the heavens themselves quite perceptibly, as can be seen by comparing it with our own picture of the same constellation and with the distribution of its stars made here, which we set out in chapter 3. And if the heavens are diligently observed, it will be confirmed that our depiction has been shaped from there, as was fitting, and not [merely] from the charts of the [older] Tables.

Next he adds a canonical exposition of 13 stars of the same constellation, anciently catalogued, resting on Copernican foundations; here he somewhat corrects the excessive irregularity admitted in the canons concerning the outermost star in the Foot, which, as we have said elsewhere, deviates by more than a whole sign — though even so it still falls short of its true longitude by $3\frac{1}{2}$ degrees.

He then subjoins the distances of this new star from six of the more select stars in the constellation of Cassiopeia, which he measured by the radius, more accurately indeed than most others; for he departs from our own findings by 3 or 4 minutes at most. But so that this discrepancy, however small, may be made plain, we shall set out below in a little table its intervals compared with our own.

Distance of the New Star from certain stars of Cassiopeia, according to Digges's observation, compared with our own.

[Margin (left, vertical): NOVA DISTABAT, à — "The New (Star) was distant, from"]

Names of the Stars	Distances — Digges's (P.)	Distances — Digges's (M.)	Distances — Ours (P.)	Distances — Ours (M.)	Differe nce (M.)	
In the Breast [Pectore]	7	47	7	50½	3½	p l u s
In the Hip or bend [Coxa seu flexura]	4	58	5	2	4	p l u s
In the Knee or ham [Genu seu poplite]	8	5	8	3½	1½	m i n u s
In the Leg [Crure]	9	45	9	48	3	p l u s
In the foot of the Seat [Sedis pede]	1	28½	1	31	2½	p l u s
At the Middle Ascent [Medio]	5	15	5	19	4	p l u s

Names of the Stars	Distances —		Distances —		Differe nce
	Distances — Digges's (P.)	Digges's (M.)	Distances — Ours (P.)	— Ours (M.)	

Ascensu]

From this it is clear that the discrepancy nowhere exceeds four minutes, as I said. In all the stars except one — the one next to the knee — Digges has a few seconds more than we do, which could easily happen, owing to the parallax of the eye [parallaxis oculi] during observation (a matter he himself treats later, in correcting for the radius), which he did not handle aptly enough. But why he should err in that one star alone I do not see, unless it is to be ascribed to carelessness in the observation. Digges no doubt believed that the distances he proposed held good to within the very seconds, and indeed he applied himself diligently to taking them, as far as could be done with the radius [radius astronomicus].

Whether he reached even the minute he supposed he had, however, we shall show by inquiring into the place of the New Star [New Star of 1572] from some of these distances, with our own verification of the fixed stars [fixed stars] brought to bear. If the place comes out consistent with itself in the very second — as ours did seven times over, hammered out under the anvil of demonstration and computation as set forth in chapter 5 — then his distances will indeed hold good to the last hair. But if some discrepancy turns up, his distances will necessarily be found less exact. To make this readily apparent, we shall set about examining those three stars from which he formed the rhombus by a threefold inquiry as well, just as we did in examining our own intervals. We shall use here the same figure we employed above in chapter 5 for a similar task. In it, as there too: E is the pole of the zodiac [Polus Zodiaci]; A the bright star of the Throne of Cassiopeia [Lucida Cathedrae Cassiopeae]; B the knee [Flexura]; D Schedir; C the New Star.

Diagram. A spherical-triangle construction, drawn as a fan of lines (great-circle arcs and chords) converging toward the pole. The point E is set high at the top; A and B lie at the lower left and lower right; C is an interior point in the upper-middle region; D is a point low and slightly left of center. Numerous straight lines connect the points, forming the several triangles (A E D, A D C, D E B, B C D, E B D) that are worked through in the text below. The figure is uncaptioned.

- E (top): the pole of the zodiac
- A (lower left): the bright star of the Throne of Cassiopeia (Schedir's "Throne" star)

- B (lower right): the knee [Flexura]
- C (interior, upper-middle): the New Star
- D (lower center, left of B): Schedir

So, experimenting first to see where the New Star comes out, if we presuppose its distances from the bright star of the Throne and from the knee according to Digges's observations with the radius: we shall first put the triangle A B E on the scale. In it, A E follows from the complement of the latitude of the Throne star, $38^{\circ} 45\frac{1}{2}'$ [Margin: $38. / 45\frac{1}{2}$]; B E is the complement of the knee, $41^{\circ} 14'$; and the difference in longitude of the two — the position of the star being P. $8^{\circ} 52'$ [recte: difference in longitude $8^{\circ} 52'$; the star's longitude] — makes manifest the angle B E A, which represents that same difference. Therefore the third side B A is $6^{\circ} 12\frac{1}{2}'$; and the angle B A E is about $110^{\circ} 2'$.

Next, in the triangle A C B, from the known side A C, $5^{\circ} 15'$, and B C, $4^{\circ} 58'$ —

both being as they stand from the distances of the New Star to the assumed fixed stars according to Digges. And from the third side B A, found earlier, the angle C A B will be established, $50^{\circ} 36'$. Subtracting this from the angle B A E found before — as a part from its whole — leaves the angle E A C known, $59^{\circ} 26'$.

Hence in the angle E A C, since the sides A E and A C enclosing this angle are settled from what was said earlier, the remaining side C E — which expresses the complement of the New Star's distance — will not be hidden: $36^{\circ} 19\frac{1}{2}'$. And the angle C E A, giving the difference in longitude from the bright star of the Throne, $7^{\circ} 38\frac{1}{2}'$, will yield the New Star's longitude as $6^{\circ} 50'$ in Taurus [♉], with a latitude of $53^{\circ} 40\frac{1}{2}'$, derived from the complement of its distance found earlier.

Now we shall attempt the same thing in the same way from the bright star of the Throne and from Schedir; and, so as not to repeat everything tediously, we shall indicate the sum of the calculation briefly. In the triangle A E D, the side E D is $43^{\circ} 24\frac{1}{2}'$; A E is $38^{\circ} 45\frac{1}{2}'$; A E D [recte: the angle A E D] is $2^{\circ} 42'$. Therefore D A is $4^{\circ} 59'$, and the angle A D E is $20^{\circ} 0'$.

Then in the triangle A D C, D C will be $7^{\circ} 47'$; A C is $5^{\circ} 15'$, according to Digges's notation; and D A, as before, is $4^{\circ} 59'$. Therefore the angle A D C is $41^{\circ} 51'$. Taking from this the angle A D E found earlier, there remains C D E, $21^{\circ} 51'$.

Finally, in the triangle C D E, from the angle already stated as known and from E D and D C given before, E C comes out $36^{\circ} 17'$, indicating the complement of the New Star's latitude. And the angle E D C, giving the difference in longitude from Schedir, is $4^{\circ} 53'$. Because of this the New Star's longitude leaps out as $6^{\circ} 47'$ in

Taurus [γ], with a latitude collected from the complement stated above, $53^{\circ} 43'$. These are the two quantities we were inquiring into here.

At last, by examining the very same thing through Schedir of Cassiopeia and its knee, the course of the operation, set out summarily, will run as follows.

In the triangle D E B: the side B E is $41^{\circ} 14'$; D E is $43^{\circ} 24\frac{1}{2}'$; the angle D E B is $6^{\circ} 10'$. Therefore the side D B is $4^{\circ} 40\frac{1}{2}'$, and the angle E B D is $115^{\circ} 2'$.

Then in the triangle B C D: the side B C is $4^{\circ} 58'$; D C is $7^{\circ} 47'$, according to Digges's observation; and D B, as before, is $4^{\circ} 40\frac{1}{2}'$. Hence the angle C B D is $107^{\circ} 41'$.

Therefore in the triangle E B D, there will be the angle at B, namely $7^{\circ} 21'$; and from the two sides E B and B C now brought to light, C E is deduced, $38^{\circ} 19'$ — the complement of the New Star's latitude. And the angle C E B, the difference in longitude of the same from the knee of Cassiopeia, is $1^{\circ} 4\frac{1}{2}'$. So the place of this star falls, as to longitude, at $6^{\circ} 59'$ in Taurus [γ], its latitude at the same time being $53^{\circ} 41'$ — just as we set out to find.

Therefore, since we now have the place of the New Star according to Digges, found in three ways by triangular computation from the three distances in the Cassiopeia asterism observed with the radius, we shall set before the eye every result as to its longitude and latitude, so found, so that it may more readily be established —

and so that it may become known that they do not converge on one and the same place, and by what mutual discrepancy they diverge from one another.

The place of the New Star, found in three ways from Digges's distances.

NAMES OF THE STARS	LONGIT. (S. ° / M.)	LATIT. (° / M.)	DIFFERENTI A — LONG. (M.)	DIFFERENTI A — LAT. (M.)	DIFFERENTI A — LONG. (M.)
I. From the bright star of the Throne & the knee [Flexura]	$6^{\circ} / 50' \gamma$	$53^{\circ} / 40\frac{1}{2}'$	3	$2\frac{1}{2}$	} 9
II. From the bright star	$6^{\circ} / 47' \gamma$	$53^{\circ} / 43'$	12	2	

NAMES OF THE STARS	LONGIT. (S. ° / M.)	LATIT. (° / M.)	DIFFERENTI A — LONG. (M.)	DIFFERENTI A — LAT. (M.)	DIFFERENTI A — LONG. (M.)
of the Throne & Schedir					
III. From Schedir & the knee [Flexura]	6° / 59' 8	53° / 41'			

From this it plainly emerges that the distances laid out by Digges do not everywhere yield the same place for the New Star — so much so that the difference from the first determination to the second is 3 minutes in longitude and 2½ in latitude; from the second to the third, 12 minutes in longitude and 2 in latitude; and from the first, finally, to the last, 9 minutes in longitude, while in latitude the three agree with one another to within half a minute. And although this threefold discrepancy is nowhere so great, however slight it may be, it nonetheless shows clearly enough the gaps — by one second or another, as the case required — in which the distances Digges measured with the radius do not hold good exactly: particularly since, between the first and third determinations drawn out, a discrepancy of 9 seconds in longitude is incurred, and between the second and third it mounts higher still, reaching 12 minutes. These are surely incoherences too great, and deserve no excuse.

But the places of the fixed stars assumed by us are thoroughly consonant with the heaven itself, as we demonstrated abundantly near the end of chapter 2, where the stars of Cassiopeia are verified from sure observations; and our distances, applied to those places by the same method, set the place of this star within the same minute, both in longitude and in latitude, everywhere. These can sufficiently persuade anyone that both the places of the fixed stars are correct and our distances liable to no fault — whereas all others that diverge from them, such as these of Digges, do not stand up to the exact standard and Geometrical test. Having thus examined and explained the matter sufficiently in this manner, we shall now turn to what Digges adds next under the title in the Preface to that little book of his.

In the Preface that follows, addressed to the searchers of Astronomy and of Celestial Wisdom, he from the outset inculcates, quite skillfully and truly, several things for the commendation of the art:

Thereafter he disputes about the hypotheses of the ancients and of Copernicus [Copernicus]; and what he there objects against those ancient hypotheses he advances not without merit. Yet whether for that reason the Copernican view, those being rejected, ought to be substituted, he has by no means proved.

But what is here properly worthy of inquiry is what he says about this New Star: that by it — had it only lasted a while longer — it could have been discerned whether the Earth moves according to Copernicus's tenets or not. I shall therefore excerpt his very own words on the matter, in which he speaks thus:

I have resolved at least to give this notice: that an occasion has been offered, and a most opportune chance, of testing whether the Motion of the Earth supposed in Copernicus's Theory be the sole cause why this Star is diminished in its apparent magnitude. For if it were so, then at the vernal equinox it would always be seen decreasing, and would be discerned at its smallest magnitude; but afterwards, if it lasted, it would gradually be seen to grow, until in the following July of the same year it would be of nearly the same brightness as at its first Apparition. At the autumnal equinox, however, it would appear of unusual magnitude and splendor. Of such a diversity of apparent quantities no other cause could be assigned than the Star's own greater and lesser distances from the Earth. For that a Star in the heaven should be increased or diminished would be not only utterly contrary to the foundations of the Physicists, but would also, by manifest measurements taken with this art, be detected to be otherwise.

This, then, is what Digges put forward in this manner, hoping to gain some support from it for examining the Theories and for establishing the true System of the World. But here he did not consider everything with the circumspection that was fitting — sharp-witted as that Mathematician was elsewhere. For this new phenomenon did not change its magnitude in proportion to the Earth's approach or recession, even granting that the Copernican reasoning, which it seems to support, could find a place. By its own nature it dwindled successively until it ceased to be seen at all. Nor ought this to seem so strange, even if it is contrary to physical principles. For if some new Star could come forth in the heaven itself — which even he does not deny — the laws of the Physicists being left out of account, it is no wonder that it should also, those being neglected, alter its quantity and at last vanish entirely. For it did not necessarily have in common with the World, as coeval with it, that it should subsist perpetually in the same body; since indeed it did not share the same principles of formation with the World.

But if, once arisen, it had retained the same quantity perpetually — or at least for a whole year — and had been situated in the Spheres of the Planets (as the Author here seems to think, by afterwards attributing to it a parallax [parallax] of nearly 2 minutes), there would indeed be no inconsistency in what he advances about its diminution and increase, provided the Earth were carried round yearly in the great Orb, as Copernicus held. Except that, in striving to establish this, he inconsiderately overturns the immobility of the place which he himself had attributed to it. For it can in no way come about that, with the Earth carried round by its Annual motion, a phenomenon somewhere within the bounds of the Planets should be at rest in itself — which, however, if the Spheres were real —

it cannot be conceded (as Copernicus too admitted) that the star should remain visible to us, while we long dwell on the Earth, under one and the same place of the eighth sphere. Digges himself, on reconsidering the matter more carefully — or once alerted to these points — will admit all this when he weighs everything more correctly. But so that others too may grasp the same point more readily, I will show it in some fashion by the diagram set out below.

Diagram. A Copernican schematic of concentric circles centered on the Sun, used to test whether the Earth's annual motion would have made the New Star vary in apparent size. At the center is the Sun, marked A. Around it runs the small annual orbit of the Earth, whose four cardinal positions are lettered B, C, D, E. Outside this lies the orbit on which Digges supposed the star to sit (among the planetary revolutions), lettered F, O, G, N. The outermost circle is the eighth sphere (the sphere of the fixed stars), lettered H, M, P, L. A vertical line — the colure of the equinoxes — runs through the figure from top to bottom, lettered (top to bottom) I, ☉H, K at the top arc, then F (the star's place), C, A (Sun), E, G, and P at the foot. Beneath P is a small bracket-like ground symbol.

- A (center): the Sun [☉], at rest in the center of the universe
- B (left, on the Earth's annual orbit): one cardinal position of the Earth
- C (above center, on the Earth's annual orbit): position of the Earth
- D (right, on the Earth's annual orbit): position of the Earth
- E (below center, on the Earth's annual orbit): position of the Earth
- F (upper, on the middle orbit): the place where Digges supposes the star to stand [shown with a star/burst mark]
- O (right, on the middle orbit): point of the middle orbit
- G (lower, on the middle orbit): point of the middle orbit
- N (left, on the middle orbit): point of the middle orbit

- H (top, on the eighth sphere): point of the outermost sphere
- M (right, on the eighth sphere): point of the outermost sphere
- P (bottom, on the eighth sphere): point of the outermost sphere
- L (left, on the eighth sphere): point of the outermost sphere
- I (top, on the upper arc): point on the colure / eighth sphere
- ☊H (top center): the sign Cancer marking the top of the colure
- K (top, right of center): point on the upper arc

Let the Sun [☉] be at rest in the center of the universe, and let B, C, D, E be the annual orbit of the Earth revolving around it. Let F, O, G, N be that orbit among the planetary revolutions where Digges presupposes the star to have stood — such that on it he allowed a parallax of nearly 2 minutes [Parallaxin 2. Minut.], which would have had to occur around the Martian revolutions nearest at hand. Let the eighth sphere, free of all parallax, be H, M, P, L. Let H, F, C, A, E, G, P further represent the colure of the equinoxes, under whose vernal semicircle the star stood, namely at F. It is indeed clear that, with the Earth located at C and the Sun at A — seen, then, at the autumnal equinox — the star would be brought nearer and would therefore appear a little larger. With the Earth around the solstices at B and D, this would hold in a middling way; but the star would be reckoned smallest of all when the Earth has rolled forward to E, with the Sun at H, producing

[Margin: 2] (*marginal numeral beside "Parallaxin 2. Minut."*)

producing [the effect]. For these are roughly the things Digges meant to say, set out visibly, so far as could be done in his plane delineation. Yet in framing such an account he failed to notice that, with the Earth placed at D, the place of the star situated at F would be shown in the eighth sphere at I; and since, with the Earth at B, the same star — at F — would be thrust out toward K in the same sphere, it could not happen that the star should appear motionless. Yet experience itself, for as long as the star lasted, sufficiently showed that it did. For by reason of the angle B F D — which the parallax from the great orbit of the Earth, after the manner of Copernicus, produces just as it does for the other planets — the star, on our revolving annually together with the Earth, would have been observed to change its place. I am therefore astonished that Digges, otherwise no careless student of these matters and — as I suppose — not the least of Copernicus's disciples, did not at all notice this, given that he places the star within the orbits of the planets and grants it rest, while he nonetheless strives to use it to explore the motion of the Earth.

But if he had set it in the eighth sphere (where in fact it really was), no handle remained for him by which to investigate whether the Earth, on the Copernican view, is carried around the resting Sun or not — since the annual orbit of the Earth is, with respect to the eighth sphere, on his own presupposition imperceptible to Copernicus. Otherwise the fixed stars too would feel a commutation of their parallax.

It is therefore quite evident that, through this star — even if it had not altered its own magnitude — the annual motion of the Earth, if any such existed, could not have been demonstrated. The star, for as long as it lasted, remained under the same place of the eighth sphere perpetually, whether or not its magnitude was altered by the approach or recession of the Earth — which in any case was superfluous, since the Earth in truth does not move, and the star diminished of itself. I admit, indeed, that in our diagram not everything is rendered exactly to scale, since the several items could not be kept in one plane, nor could the magnitudes and proportions be preserved; nevertheless, for those who understand the matter itself, I judge this representation satisfactory.

I will add this too. With the Sun moving around the beginning of Scorpio [♏], the new star ought rather to have appeared at its largest, and at its smallest in Taurus [♉], if this difference could have arisen from the annual motion of the Earth — and not so precisely in Libra [♎] and Aries [♈] [recte: at the equinoxes], when the Earth, on the Copernican view, marks out the ecliptic by the annual motion of its center, by no means the equator. And the Earth was nearer to the star when the star was around the beginnings of Taurus [♉], with the Sun seen in Scorpio [♏], than when the Sun was in Libra [♎] and the star in Aries. For the star's longitude was about 7 degrees of Taurus [7. Grad. ♉]. And although the great latitude could in these matters be displayed quite otherwise than for the planets, yet because this latitude was less than the declination itself, the Earth would then have been nearer to the star than when it was set above the beginning of Aries [♈] — although these points need no great discrimination on their own account, since everything that Digges, by reason of the annual motion of the Earth, strove to attribute to this star

in no way deserves its place, nor are these points consistent with one another. If anyone wishes to establish the annual revolution of the Earth as a favor to Copernicus, he must seek the proof elsewhere: here he finds none.

I do indeed grant that those circuits of the five planets, which the ancients assigned to epicycles, are unfolded very neatly and with much less trouble on a single Earth [in vnica Terra]; that many absurdities committed by the ancient

mathematicians were guarded against by Copernicus; and that the celestial appearances were satisfied somewhat more accurately. Yet since we have accomplished the same thing equally well — indeed no less correctly — by another line of reasoning in our own hypothesis, why is there need to fashion (against all physical truth, and what is worse, against the authority of the Sacred Scriptures, which ought to count for most) some star out of the Earth's opaque, gross, and sluggish body — a star revolving even more manifoldly than the rest, in that it is subject to a threefold motion? But of these matters I dispute more fully elsewhere.

If Digges can demonstrate the contrary by the firmest proofs — as he promises at the end of his preface — let him by all means produce them, if he knows the matter to be necessarily so, with sound evidence. And if then no room is left for just contradiction, the Copernican paradox of the Earth's motion will at last prove not to be exploded.

But this too must not be passed over: that a little earlier he reports that, if the parallaxes of the three most remote planets can be truly observed by any art, they can be found either by these his following Problems, or by no geometrical precepts whatever. Yet he is not unaware that these three planets undergo a certain proper motion; and whoever readily exhausts the very small parallax even in the slowest planet, Saturn — since all his Problems presuppose that the phenomenon is moved by nothing but the motion of the universe — how, I ask, will he unravel the parallaxes of these planets from them? If he hopes to accomplish it from their stations, those do not last long, especially in Mars [♂], and the times of those stations are not so precisely known that the parallaxes could then be examined accurately enough — even if, by his procedures, it could be done at all. I say nothing of the fact that the variation of latitude introduces some hindrance, and that since this subtle inquiry ought rightly to be set up by comparison near the meridian — at the horizon in a lower position, at a higher one nearer the meridian — that observation made in a low position is liable to the impediments of refraction; while one high up, near the summer solstice, contributes nothing here on its own. Intermediate examinations are less distinguishable, so that to perceive thoroughly the parallaxes of the three superior planets seems too inaccessible — let alone that one might be permitted to arrive at it by such means. We, however, have not left the attempt untried, by a certain other method, in Mars at opposition [Mars Acronychio]; and, as we hope, we attain it surely enough — as we shall disclose more fittingly elsewhere.

In the proem, next, of the other [treatise], he truly pronounces this phenomenon — that it had no other proper motion than what comes from the universal diurnal revolution, to which it too exactly conformed, whether that revolution be in the heavens, as has long been the received view, or in the rotation of the terrestrial globe, as that eminent man Copernicus lately maintained that it is brought about. For altogether, as regards itself, this star was motionless: of which matter this is not now the place to dispute. Elsewhere I shall resolve this doubt about the diurnal motion — which is not, as some think, so trivial a question. Rightly, therefore, did he presuppose the star's inherent immobility as the foundation for investigating the parallaxes — although he sought these too there in vain, where there were absolutely none; and his labor was no less assuredly fruitless than that of anyone who should presume to measure the parallax of some fixed star.

He does not unjustly disapprove of Regiomontanus's [Regiomontanus] computations regarding the investigation of parallaxes, on the ground that they require moments of time that are by their nature doubtful to be precisely known — although these too can be diagnosed accurately enough by a certain special instrument and with appropriate diligence. It is indeed required, in order that the practical work by which this is carried out be fittingly verified and exactly consonant with the heavens (which can also be achieved), that we nevertheless use the same star at both times of observation; the deflection from the mark aimed at will be imperceptible in respect of time, however much it may stand in its position — as much in longitude as in latitude — with some small deviation.

He afterwards makes mention of a certain writing by that most noble and most distinguished philosopher and mathematician John Dee of London [Iohannis Dee Londinensis], who, regarding this star observed very many times with unusual instruments, had ready to publish a work which we have nevertheless not yet seen, nor have I learned from anyone that it has so far been made public. I suppose that he, since he detected the parallax to be immeasurable on account of its imperceptibility (for in truth it had none), removed his hand from the table; yet I judge that even this pointing-out was useful.

As for his Problems, and the Lemmas and Corollaries interwoven with them, which he afterwards appends, I do not wish to discourse at length for the present, for the reason that he nowhere subjoins to his Demonstrations the parallax of this star derived from a sure observation, nor adapts their use by an example fitted to these matters. Yet these very Problems are in themselves devised and arranged with most shrewd industry and ingenuity. But, to tell the truth, their

use and application do not match the labor — since they find a place only in phenomena that are moved by no proper motion at all, and conform solely to the universal diurnal motion: which are surely very rare cases. For apart from this new star, scarcely any such body, destitute of all motion except the diurnal revolution, has been observed in very many years past.

As comets appear quite frequently, and since almost none of them lacks a peculiar motion of its own, scarcely any use will be found even for these Problemata — that is, for discerning the parallaxes of comets. For the parallaxes of comets are not so large as has hitherto been believed, so large that their proper motion could on their account be reckoned negligible. On the contrary, since these parallaxes are very small — inasmuch as all comets are in fact situated in the heavens — they are cancelled out by the comet's own proper motion. Nor do they lend themselves to the close investigation called for by such doctrines. The same holds for the Problemata that Regiomontanus [Regiomontanus] devised for this very purpose: they do not stand up, for the same reason, any more than do those which Thaddaeus [Thaddaeus Hagecius] and Witich [Paul Wittich] later added. For all of these presuppose a phenomenon free of proper motion, and so they earn no place among comets, very few of which — or rather none — lack such motion.

Furthermore, most of the matters that Digges [Thomas Digges] assembled with such care, even granting that they are sound as demonstrations, nonetheless, when it comes to practice and application, do not deliver in the end what they seem to promise at first sight. For certain data are required from time to time which, demanding the utmost precision, are not everywhere easily available or able to be supplied. As a result, the labor is wasted, and the undertaking does not reach its intended goal.

Indeed, to define parallaxes through so many windings and labyrinths — especially if they are very small — entangles the task more than it disentangles it, since even the tables of sines, computed with such fine workmanship, are not everywhere adequate to the operation. That this did not escape Digges himself is plain from the fact that he afterward singles out certain Problemata and gives them preference over the rest for reliability of use.

He could certainly have set out most of these by a far easier method and in a simpler form, so that the procedure of demonstration might be less complicated — and it is precisely on this that a mathematician should expend his effort. In some of these very Problemata of Digges, this is what D. Thaddaeus and Witich accomplished, both on the assumption of the earth's rest and on Copernicus's

[Copernicus] daily rotation of the earth. Some of these Thaddaeus appended to his enlarged *Dialexis*.

So that Digges himself, as well as others, may see how easily these matters can be reduced to a different demonstrative form, I shall here add — drawn from the said renewed *Dialexis* of Thaddaeus — three of Digges's Problemata, clothed in another and simpler dress, together with Thaddaeus's own words and the course of his demonstration, altering nothing in them. I do this so that, in case his renewed *Dialexis* should perhaps not come out, students of these matters may at least obtain this much of them from here. For I know that I am sharing these labors of his with others by the kind leave of their author.

Thaddaeus's First Problema, taken from Digges XI & XIII.

Given two altitudes of the phenomenon — the greatest, namely, and the least — when they have stood in the same vertical circle; or if one of them be given under one vertical toward the East and the other under a different vertical toward the West, provided each vertical is equally distant from the meridian, and one of the altitudes be the greater, the other the lesser: and given also the elevation of the pole, without any consideration of time, to find the sum of the parallaxes.

Let the greatest circle be drawn through the points of rising and setting and through the zenith: B A D, in which A is the zenith, B the place of rising, D the place of setting. B C D is the horizon, A H C the meridian, H the pole of the world. Let the parallel circle which the phenomenon describes by the motion of the firmament be E N P F. Let the vertical circle touching the inner parallel at the point X. Let the circle cutting the two other parallels — of the true and of the apparent place of the phenomenon — be A G N I, in which the true places of the phenomenon are E and N, and the apparent places G and O.

Diagram. A celestial-sphere construction shown as a great almond-shaped (vesica) outer boundary representing the great circle through the rising point, setting point, and zenith. The zenith A sits at the top apex; B (lower left) is the rising point and D (lower right) the setting point. Three nested parallel circles are drawn around a central pole H. Two oblique vertical-circle lines radiate from the apex A down through the figure, crossing the parallels and meeting near the lower margin at I, G, K. Several positions are marked with small comet/star burst symbols.

- A (top apex): the zenith
- B (lower left, on outer boundary): the rising point (Ortus)

- D (lower right, on outer boundary): the setting point (Occasus)
- H (center): the pole of the world
- E (upper area, left of center, on a parallel): true place of the phenomenon
- F (upper area, right of center): point on the apparent-place circle
- G (left, with burst symbol): apparent place of the phenomenon
- X (left of center): contact point of the vertical with the inner parallel
- L (right of center): contact point (paired with X on the other side)
- S (lower left of center): point on a parallel
- T (lower right of center): point on a parallel
- N (lower left, with burst symbol): true place of the phenomenon
- O (lower left, below N, with burst symbol): apparent place
- P (lower right): point on a parallel
- R (lower right, with burst symbol): apparent place
- I (bottom left): foot of one oblique line on the boundary
- G (bottom center): point on the boundary
- K (bottom right): foot of the other oblique line on the boundary

In the other vertical toward the West, which is A F L K, as far distant from the meridian A H C as the former, the true places are F and P, the apparent Q and R. The arc S O, or T R, which are what is sought as the sum of the parallaxes, must be found. Let the points of the true places of the phenomenon on the circumference of the parallel be joined by arcs of great circles from the pole of the world H — namely H E, H N, H P. Then from the same pole H, to the points of contact X and L, let the arcs H X and H L be drawn. Since the greatest circle A X I touches the inner parallel circle at the point X, and through that same point of contact the greatest circle H X passes from the pole of that same parallel, H, therefore that same circle passes through the poles of A X I; and by Theodosius I.20, the circle H X cuts the circle A X I at right angles. The angle A X H is therefore a right angle.

Again, since of the two triangles A H E and A H F, the side H E of triangle A H E is equal to the side H F, while the side A H is common to each triangle, the two sides A H and H E of triangle A H E will therefore be equal to the two sides A H and A F of triangle A H F, the one to the other; and the angle H A E is equal to the angle H A F, by hypothesis. Therefore, by Copernicus I.8 — or I.55 — and by Regiomontanus III, *On Triangles*, the remaining sides A E and A F will be equal. And since the parallaxes of equal altitudes of the phenomenon in different verticals equally distant from the meridian are themselves equal, E G (the

parallax) will be equal to the parallax FQ , and SN to TP . If, then, these equal arcs AE and AF are added to the equal arcs between them AG and AQ , their complements GI and QK will likewise be equal. By the same reasoning it is proved that OI is equal to RK .

Again, since the circle of altitude $AENI$ cuts the two parallel circles $ENPE$ [recte: $ENPF$] and $GSTQ$ in its upper and lower parts, therefore by Theodosius II.13 the arc EG is equal to the arc SN , and FQ to TP ; likewise GX to XS , and QL to LT .

With these things constructed and demonstrated, we shall proceed to the inquiry into the angles and sides as follows. Whether you have two altitudes in the same vertical, or in different ones — provided that one of them is the greater and the other the lesser — for arriving at knowledge of the sum of the parallaxes:

I take the right triangle AXH , in which AH , together with the angle XAH , are known, and the angle at X is a right angle. The side AX will therefore be given by Copernicus I.3, and its complement XI ; and since IG , or KQ , are equal and known by hypothesis, and likewise IO , or KR , are known: subtracting IO from the side IX , taken from IG , the remainder is XG , to which XS is equal; and with IO subtracted, there remains OX . Again, subtracting XS from XO , there remains the arc SO , which is composed of the two arcs SN and NO — that is, of the parallax of the upper part, or of the greater altitude of the phenomenon (for we proved that SN is equal to EG), and of the parallax of the lower part, or of the lesser altitude. The whole arc OS , therefore, is the sum of the parallaxes — which was to be done.

Not unlike this Problema just set out is also Digges's fifteenth Problema, which teaches how to investigate the sum of the parallaxes from three given quantities — except that, in place of the altitude of the pole, which it there took as a datum, it here assumes the distance from a fixed star in the same verticals. That Problema runs as follows.

Thaddaeus's Second Problema, taken from Digges XV, arranged somewhat differently.

Given two altitudes of the phenomenon, and its distances from some one of the fixed stars, when these have been taken in two verticals equally distant from the meridian on opposite sides, to gather the sum of the parallaxes.

I shall not add the demonstration, lest I seem to pour out words rashly. It can be sought from the foregoing Problema. I shall add at least the diagram and the

operation. You see in the present diagram the apparent point of the phenomenon O, and the star G, in the first consideration, to be in the same vertical. Given therefore, from the first observation, the altitude of the phenomenon Q O, and that of the star Q G, and subtracting Q O from Q G, there remains O G, the distance of the phenomenon from the star — unless one prefers to measure it by the instrument.

Diagram. A second celestial-sphere construction of the same vesica (almond) form, with zenith A at the top apex and B (lower left) and D (lower right) at the outer boundary. A central pole-point sits at the middle of the figure, with H marked below center. Concentric circles surround the center, and oblique lines radiate from the apex A through the figure to the lower points C and S near the bottom margin. Small comet/star burst symbols mark several positions.

- A (top apex): the zenith
- E (upper left of center): point on a parallel / true place
- I (upper right of center): point on a parallel
- G (left of center): point on a parallel (apparent place of the star)
- R (upper right, with burst symbol): apparent place
- P (right of center): point on a parallel
- X (left of center): point on the inner parallel
- T (right of center, with star symbol): point on a parallel
- H (below center): the pole of the world
- B (lower left, on outer boundary): the rising point
- D (lower right, on outer boundary): the setting point
- O (lower left, with burst symbol): apparent place of the phenomenon
- C (bottom center): point on the boundary
- S (bottom right of center): point on the boundary

Again, in the second consideration, when they have come together under a similar vertical on the opposite side, with the arrangement inverted from the former as you see in the diagram, take the altitude of the star S T, and that of the phenomenon S R, and subtract the latter from this: you will have R T, the distance of the phenomenon from the star in the second consideration. Now subtracting these two distances of the two considerations from one another, the sum of the parallaxes will remain, composed of the arcs O H and R I.

Problema XVII, Digges, under a new form.

If a phenomenon stand with two fixed stars under the same vertical, first take, at that very moment, its apparent distance from each of the fixed stars. Then, the phenomenon having been carried by the motion of the firmament under another vertical — as far distant from the meridian on the opposite side, in the horizon, as it was before — take again its apparent distance from the same fixed stars, and the altitude of one or the other of the stars, and so draw out separately the parallaxes for each of the two times.

This Problema, which corresponds to Digges XVII, has — like all the rest — a most firm and most evident demonstration. But if it be applied to calculation, it can hardly be carried through without error, on account of the excessive smallness of the angles I and H of the triangle I L H, and the magnitude of the obtuse angle at L in the diagram set below. For since parallaxes are concerned with the smallest quantities, it could happen that, because of the smallness either of the sides or of the angles, or of both at once, the sides I L and L H of the triangle I L H fall onto the very arc I H itself. Add to this that even our tables, in this part, are not yet accurate enough — tables which, for greater certainty, it would be necessary to have extended even to second minutes [seconds]. Finally, with regard to the consideration of azimuth of this kind, no small difficulty can arise.

I write this to remind students of mathematics that, in observing celestial phenomena, they should bring the utmost diligence to bear, and that they should make their choice among these Problems—whether the ones handed down by us or by others—accordingly. Digges himself also warned the reader of this point. In short, let them adopt observations of the kind that will be least liable to error, and let them avoid, so far as is possible, the smallness of sides and angles. This precept students of mathematics ought always to keep in mind.

So let the meridian be A B C, the horizon A E C, and the vertical circle of the first observation B D. On this vertical circle let the two fixed stars be H and I. Let the apparent place of the phenomenon be K, and its true place G. Let the distances of the phenomenon from each of the marked stars also be noted there—that is, H K and I K.

Diagram. A spherical (hemisphere) construction shown as an oval. The outer curve is the great circle of the sphere; the meridian and horizon are drawn within it. The labels read, working around the figure:

- B (top): the zenith / vertex, common point of the meridian and the verticals

- D (left): endpoint of the first vertical circle on the horizon
- A (lower left): point of the horizon (meridian–horizon intersection)
- E (bottom): point of the horizon
- C (lower right): point of the horizon (meridian–horizon intersection)
- H (left, on the first vertical): one of the two fixed stars (shown twice—once upper, once at D side)
- I, G (upper middle): the fixed star I and the true place G of the phenomenon
- K (upper left, marked with a comet/tailed-star symbol): the apparent place of the phenomenon in the first observation
- I, G (middle): repeated star I and true place G for the second configuration
- K (middle, tailed-star symbol): apparent place of the phenomenon in the second observation
- L (lower middle, tailed-star symbol): the apparent place of the phenomenon carried over by the motion of the firmament in the second observation
- H (lower middle right): the fixed star H in the second configuration

The tailed-star (comet-like) symbols mark the phenomenon's apparent positions.

Next, let the vertical circle of the second observation be B L E, as far distant from the meridian B A as the first one was from the same. On this vertical circle the apparent place of the phenomenon, carried over by the motion of the firmament, is L—equally distant from the point G, the true place of the phenomenon in the first consideration. Marked with the same letters as before, the points are I, H, K. For in this second observation they will hold this same position relative to one another. Let the points L, I, H be joined by arcs of great circles, I L and L H.

I say that the parallaxes of both considerations can be determined—namely the arcs L G and G K. For since in the two observations the distances of the phenomenon from the stars—that is, H K, K I and L H, L I—are known, we have the triangle L H I, whose sides are known. Therefore, by Copernicus XIII, its angles will be known, and above all the angle I H L. Likewise we have another triangle B L H, in which again three sides are known. Therefore, by the same proposition, the angles B H L and H B L become known. Now, if you subtract the angle I H L from the angle B H L, the angle B H G remains. Finally we have the triangle B H G, in which two angles, B H G and H B G, together with the adjacent side B H, are known. Therefore, by Copernicus XII, the sides B G and H G are given, and hence the parallaxes of both times—namely the sides K G and G L. Which was what we set out to establish.

Problema XIX ex Diggeseo sub alia forma

Problem XIX from Digges, in another form.

When the phenomenon lies on the same vertical circle with two fixed stars, and when at that moment the apparent distances of the phenomenon from each star have been taken, and again in the second observation—without regard to the vertical circles—the distances of the phenomenon from the same fixed stars have been taken, together with the altitude of the phenomenon: to determine the parallaxes of either one of the fixed stars, congruent with the time.

This Problem, which corresponds to Digges's Problem XIX, differs from the preceding one only in this: that in the former the vertical circle of the second observation was assumed to be on the side opposite to the meridian, at the same horizontal distance at which it stood in the first observation, whereas in this one that distinction is disregarded. The problem could have been omitted, were it not that we judged Digges wished to display the variety of methods.

So let the meridian be A B C, the vertex B, the horizon A M C, and the pole of the world D. Let the vertical circle of the first observation be B H N, on which let there be two fixed stars, H the higher and G the lower.

Diagram. A hemisphere drawn as an oval, with several great-circle arcs (verticals and the horizon) crossing through a central region of star and phenomenon marks. Readable labels, working around the figure:

- B (top): the vertex / zenith
- D (upper right): the pole of the world
- A (left): point of the horizon
- C (right): point of the horizon
- M (bottom): point of the horizon (meridian foot)
- L (bottom, right of M): point on the lower arc
- N (lower right): foot of the first vertical B H N
- H (upper middle, two positions H ... H): the higher fixed star, shown in both configurations
- G (middle, two positions G ... G): the lower fixed star, shown in both configurations
- E (middle left, tailed-star symbol): apparent place of the phenomenon
- F (middle, near E and again lower right): true place of the phenomenon

- K (center, tailed-star symbol): apparent place of the phenomenon in the second observation
- E (lower right, tailed-star symbol): the phenomenon's apparent place in the second configuration

The tailed-star symbols mark the apparent places of the phenomenon.

The true place of the phenomenon is F, the apparent place E. The stars named, together with the phenomenon, are carried by the motion of the *primum mobile* into another place, in which they will hold the position in the heavens that you see in the attached diagram. The stars and the phenomenon are marked with the same letters on the arc of a great circle, where the distances of the phenomenon from the fixed stars are represented as they were in the first observation. But in the second observation they are represented by the arc K G and K H. For K is the apparent place of the phenomenon in the second observation; the true place is F, on the vertical B F M. Another vertical drawn through the star G is B G L. I say that the parallaxes F E and F K will be determined.

Since E G, E H are known from the hypothesis of the first observation, and K G, K H from the hypothesis of the second, the triangle K G H will have known sides. Therefore, by Copernicus XIII, its angles too are known, and above all the angles G H K and G K H. Again, in the triangle E H K, two sides E H, H K are known from the hypothesis, together with the angle E H K comprehended by them. Therefore, by Copernicus XI, E K will become known, and the remaining angles E K H and H E K will not be unknown. Third, we have the triangle K B G, all three of whose sides are known from the hypothesis. For K B is the distance of the phenomenon from the vertex in the second observation, while G B is the distance from the vertex of the star G, and K G is the distance of the phenomenon from the star. Therefore, by Copernicus XIII, the angle B K G will become known; and added to the angle G K H, it will yield the whole angle F K H known. This in turn, subtracted from the angle (in the first triangle) E K H, will leave the angle E K F. Finally there is the triangle E F K, in which the side E K, together with the two angles adjacent to that same side, are known. Therefore, by Copernicus XII, the parallaxes of both times will become known—of the first consideration the parallax E F, and of the second consideration K F. Which was what had to be done.

Problema XX ex Diggeseo, alia & magis succincta ordinatione

Problem XX from Digges, in another and more compact arrangement.

In two observations of the phenomenon, given its distances from any two stars whatever, and the apparent altitudes of all three, and given also the distance of the fixed stars from one another: to investigate the true parallaxes congruent with their altitudes.

This Problem, which corresponds to Digges's Problem XX, is clothed in a new guise and is the most laborious and most difficult of them all. For it is worked out by means of seven triangles; and it has data of the following kind, of which two must be taken at one moment in the two observations—namely the altitudes of the two fixed stars and of the phenomenon. Likewise its distances from each of the fixed stars, which indeed cannot be taken from a single observer at one moment. Nevertheless it has pleased us to add that point and to set it forth in this arena under another guise, so that the variety of the parallaxes to be investigated may become known. Now this difficulty could be relieved if a partner in the observations were employed, and two quadrants, so that the altitudes of all three could be taken at one moment. For the distances do not change so suddenly as the altitudes. Yet even with that precaution you will hardly carry the matter through completely without something arising over which you might hesitate. And so I do not advise that it be put into practice. The demonstration, to be sure, is here too infallible.

So let the meridian be $M A O$, the vertex A , the pole of the world Q , and the horizon of the first observation $M R O$. Let the first vertical of the phenomenon be $A I N$, on which its apparent place is I and its true place G . Let the places of the fixed stars K and F be on their verticals $A K L$ and $A F R$. Let the vertex A of the first consideration now be carried over into the point E of the second consideration, whose horizon is $B D C$, the vertical circles of the stars being $E K S$ and $E F P$, and that of the phenomenon $E H D$, on which its apparent place is H . Let the points K, F, I, H be joined by arcs of great circles. I say that $G I$, the parallax of the first consideration, and $H G$, that of the second, will be given.

Diagram. A large hemisphere drawn as an oval, with many great-circle arcs (the two horizons and the verticals of the two considerations) crossing through a dense central web of star and phenomenon marks—the seven-triangle construction of Problem XX. Readable labels, working around the figure:

- A (top): the vertex of the first consideration
- Q (upper right, cursive): the pole of the world
- E (right of center, upper): the vertex of the second consideration
- O (right): point of the horizon

- B (left): point of the second horizon
- O (far right): point of the horizon (meridian foot M A O)
- C (lower right): point of the horizon
- M (left of center): point on the meridian / first horizon
- K (center, with tailed-star symbol below): place of the fixed star K
- G (center): true place of the phenomenon
- F (center right, tailed-star symbol): place of the fixed star F
- H (center, tailed-star symbol): apparent place of the phenomenon (first consideration)
- I (center, tailed-star symbol): apparent place of the phenomenon
- L (lower left): point on the vertical A K L
- S (lower left): foot of the vertical E K S
- N (bottom center): foot of the vertical A I N
- R (bottom center, cursive): foot of the vertical A F R
- D (lower left): point of the second horizon B D C
- P (bottom): foot of the vertical E F P

The tailed-star symbols mark the stars and the apparent places of the phenomenon.

Now in this demonstration we shall conceive seven spherical triangles. The first triangle is A K F, of known sides; therefore the angle A K F is given here. The second triangle K E F, also of known sides, makes the angle E K F known; this, subtracted from the angle A K F already found, leaves the angle A K E known. The third triangle A K E has two sides together with the included angle known. The side A E and the angle A E K are given. The fourth triangle A F E is of known sides; the angle F A E is given. The fifth triangle I A F is of known sides; the angle I A F is given, which, added to the higher angle F A E, creates the angle I A E. The sixth triangle K E H is of known sides; the angle K E H is given, to which the angle A E K is added, generating the whole angle A E G. The seventh triangle A E G has one side, A E, known together with the two adjacent angles. The remaining two sides, A G and E G, are given. Therefore G I, the first parallax, and G H, the second parallax, become known.

It could happen that the stars have a different and contrary relation to the phenomenon than the one we here suppose—say, because the phenomenon turns out to be above, or below, the stars. But neither the demonstration nor the procedure will vary, except perhaps by a trifle. A moderately practiced person

will easily extricate himself in such a case, and will easily be able to fit all the variations to the doctrine we have set out.

And let it suffice to have brought this much here from Thaddaeus's renewed dialectic. Elsewhere I shall share with students of these matters, from Thaddaeus himself and from Wittich [Witticus / Paul Wittich], much more concerning these reasonings, together with their particular Problems, along with our own observation.

It is therefore clear that those Diggesian Problems could have been set out and demonstrated far more simply and plainly. Would that the practical usefulness at least matched the labor — that they could be carried over into practice without obstacle or deviation, and that the data on which they rest could be properly supplied. *Here is the task, here the toil.*

But to say what the matter itself demands: these and similar things are correct enough in speculation and demonstration, but not so in actual practice. We must therefore be careful everywhere not to assume the kind of data, and the kind of demonstrations, that practice admits only with difficulty.

Afterward Digges appends certain supplements concerning the Astronomical Radius [Radius Astronomicus] — useful and indeed necessary ones — for in the little preface set there he prefers this instrument to all the instruments of the ancients and the moderns. As for whether it may be admitted for most purposes — well, I would not say it is admitted for all. The correction of the eye's eccentricity that he adds was clearly necessary, as were the other points that guard against errors and rightly deserve attention; and the subdivision of the instrument itself by means of finely cross-hatched lines [per lineolas transversaliter punctuatas] is highly useful and convenient, since the Radius is thereby divided into very many small parts. He asserts that this method has long been in use before his time in England, transmitted to him by hand in particular from a certain most skilled mathematician, Richard Cantzler [Richard Chancellor]. For my own part, I had this same kind of partitioning of the Radius in use much earlier — about 28 years ago at least, when I was pursuing my studies at Leipzig — communicated to me from the workshop of the distinguished mathematician Homelius [Johannes Hommel], through the good offices of Bartholomeus Schultetus [Bartholomäus Scultetus], who had assisted him. But where Hommel in turn drew it from, or whether he devised it himself, is uncertain to me. Whosoever it may be, the distribution is certainly ingenious and exceedingly useful, and I too afterward applied it — not inelegantly or unprofitably — to the arc-subdivisions of degrees on quadrants, sextants, and

armillae. For although his demonstration of it holds exactly only on flat rectilinear surfaces, nevertheless — since on larger circumferences the span of five or ten minutes differs imperceptibly from a straight line — its use here too can be sufficiently convenient and reliable; and it is found to be much handier and more suitable than Nonius's [Pedro Nunes / Nonnius] intricate and difficult subdivision of the many arcs. Yet to speak of the Radius instrument, so highly commended by Digges, I shall say what daily experience has taught me. However it is finally fitted out, and however great its length may be, and however finely it is divided — even if the eye's eccentricity is sufficiently guarded against, a perforation or small dioptric slit [foramen sive rimula Dioptrica] is applied at its beginning, and however much it be made of solid metal, hollowed out, whether four-sided or three-sided, and is moreover mounted on a support adjustable to the plane of any of the stars, and provided with still more aids for preventing error if one likes — nevertheless it will not everywhere supply, by a constant and indubitable method, the fixed and exact intervals between stars, especially the larger ones. The reason for this

I shall set out sufficiently, with the favor of the supreme Godhead, in my book on the Mechanical Practice of Astronomy [*Mechanica Astronomiae Praxis*].

Furthermore, the handling of the Radius itself is too tedious, and it is by no means easy to carry about or convenient, because it has to be removed from the eye so many times in order that the sights [Pinnacidia] may be arranged for proper collimation. And even then it is not certain enough whether this is done centrally upon the stars, since the alignment is carried out within at least the two edges of a pair of sights — as I shall make plain, when these and other impediments of the Radius are dealt with in their own place, as I have said.

But should anyone meanwhile doubt whether the matter stands thus, let him observe — with everything prepared with the utmost care and all its precautions — the distances of four or five stars set in a straight line or nearly so, taking the distances of pairs separately in succession, and then let him afterward combine them together. He will find every time that the sum of all does not exactly equal the interval of the two most distant stars likewise taken with the instrument, but that something is always either over or short. And if it should happen, after many trials, that a uniform agreement sometimes emerges, this is by chance rather than by skill, nor is it known whether it would hold true on other occasions — so much so that the measurements made with the Radius are nearly always doubtful, and one may well question whether they are exact, as in celestial matters they ought to be.

Indeed, to make a fuller test of this matter, let the distances of six, seven, or eight stars around the zodiac or the equator be taken with the Radius, the stars being far apart from one another, so that they enclose the whole circuit of the sky; and let the declinations of these same stars be carefully ascertained from their meridian altitude, or by any other method (just as we ourselves have done in practice several times in chapter 2 of this work). One will by no means find that the angles of the differences of these stars, all gathered together at once, complete the entire circle exactly, so that neither a gap nor an excess is committed. Yet this is precisely what ought to happen, if the distances taken with the Radius were free of every fault. Now in declinations of one minute or another (provided those stars are not removed too far from the equator), the aberration introduces only a very slight discrepancy — and so, with distances less suited to the purpose, this does not arise solely from this source.

And so that we need not seek examples from far afield in proving the unreliability of the Radius: those very distances of the New Star [New Star of 1572] from the older stars in the asterism of Cassiopeia, which Digges himself at once set down on the frontispiece of his little book, sufficiently testify that the Radius does not fulfill its function even in such close-set distances — much less in larger ones, where it is more prone to error. For a deviation of three or four scruples [scrupuli — i.e. minutes], within eight or nine degrees, and indeed in still smaller intervals, is committed there — as became clear from the comparison and verification I gave above. Nor do I doubt that Digges applied greater diligence than most others in rightly making and using the Radius — which is plain even from this, that he restores much concerning its use that had not been explained even by Gemma Frisius [Gemma Frisius] himself, the chief cultivator of this instrument. Nevertheless, granting that he

did not attain the matter "to the very point" (as the saying goes) with the Radius, far less did others, who did not so circumspectly and accurately forestall the many occasions of error, achieve it.

And so let this much, on the Radius — which is indeed sound as regards demonstration, yet insufficient in actual use — be reckoned a sufficient warning in this place. Let whoever wishes test what we have said; he will find the matter to be so. This we ourselves learned long ago, not without the grievous loss of many observations and many nights spent watching to no purpose, until, grown more experienced, we devised other instruments subject to no fault for searching out the intervals of the stars — of which we shall treat in their own place. Meanwhile let others who practice these things keep this forewarning,

commended to them — as I hope — as something that will spare them an expense of time and labor.

To this appendix on the correction of the Astronomical Radius, Chapter IX subjoins the method of determining the true diameter [of the New Star] from the given distance of the phenomenon from the eye and the angle of its apparent diameter found by the Radius, together with the method of recognizing it. But since these matters are entangled with no great difficulty of their own, and since they were not carried through to practice in the case of this New Star as fully as would have been fitting, I am unwilling to repeat them here at greater length.

In the tenth and final chapter we shall look somewhat more closely at those things which more nearly concern the consideration of this Star itself — which, even though for that reason they are somewhat foreign to the subject proposed, we shall now examine a little more carefully. And so that this may be done more conveniently, and that what Digges chiefly contributed to the matter may become more fully known besides — apart from the distances, of which we have spoken, around this Star, as regards his observations of it, and especially regarding the parallaxes, which he set forth in that little book — we shall append that whole tenth chapter, which runs as follows.

The Tenth Chapter of Digges, drawn from his little book of *Wings, or Mathematical Ladders [Alae seu Scalae Mathematicae]*, in which are comprised those things that chiefly concern this Star, and that were set forth by him about it

Anyone, even one wholly unskilled in astronomical computations — provided only that he is not entirely devoid of common sense and judgment — can clearly discern the errors of those who suppose this unusual Star (placed below the Moon, in the Elementary Sphere) to have a parallax greater than the Moon's.

You should have a rule five or six feet long, made of wood, or rather of metal, so fashioned that its sides are both perfectly straight lines and exactly parallel to one another. Its breadth does not matter; let it, however, be half a foot or more. Then upon a stake six feet high, fixed in the ground, let one end of it be so connected that the other end of the rule can be carried around in a circle on every side. And when you wish to test whether the phenomenon has a

parallax, do as follows. First set the rule perpendicular to the horizon — which you can most easily do with a plumb-line of any sort, using a fine thread with any weight you please attached to it. Then, looking backward along the phenomenon (the eye being always positioned in this manner), so that the phenomenon appears to be cut as it were through the middle by the edge of one of the sides, observe carefully whether that same edge at the same moment also intersects through their centers some other two fixed stars besides. You will be able to discern this most exactly by considering the edges of the rule, the phenomenon, and the fixed stars through both [edges of the rule]: for you will never be able to view them at the same moment through both edges of the rule together, unless they pass through the centers of their vertical [circle] — and the farther the eye is from the rule, the more exactly and clearly will you discern their positions. But if you should observe none under the same vertical with the phenomenon, you may make the test at various other times; for the verticals are continually changing, and new stars continually attach themselves to it [the phenomenon]. When, however, you have found some agreeing with it quite to the line, you will carefully mark them; and as soon as they have declined, you will incline the rule accordingly, and shift your eye as well, moving it this way and that, so that the edge of the rule may pass most exactly through the centers of the fixed stars. Then, if the phenomenon has any parallax, it will not be seen on the edge of the rule [in ipsa Norma acie], but lower and nearer the horizon. But so that you may recognize the truth of the matter most plainly, six or seven hours after the first vertical-circle observation you can test (using the rule's edges applied to those same fixed stars) whether the phenomenon agrees with them exactly, or rather declines from them. If there is no difference, and it seems even then to coincide most perfectly, it has no perceptible parallax at all; but if it departs from it [the rule's edge], it certainly does have a parallax. And how great it is exactly, the earlier Problems will teach. By this method, on very many nights, I observed this marvelous phenomenon to appear in one straight line — that little star which is in the knee of Cassiopeia [in genu Cassiopeae], and another which is on the right side of Cepheus below the girdle [in latere dextro Cephei sub Cingulo]. So too it agreed most exactly with the one in the hip of Cassiopeia [in Coxa Cassiopeae], and another in the left shoulder of Cepheus [in humero Cephei sinistro]. Nor could I, by these same straight lines (the circumferences, that is, of the greatest circles), perceive the phenomenon depart through the whole night — this in the month of February — by so much as the sole amount of its semidiameter of latitude. From which it can most truly be concluded that its maximum parallax at this time cannot reach two little minutes [duo minutula].

In another way, too, by sight alone, without any instrument, anyone can by this art discern the ravings of those who suppose it to be in the Elementary Region below the Moon and to have a conspicuous parallax greater than a whole degree: namely, if he is willing to compare its position only with that other little star which is at the foot of the Seat of Cassiopeia [in *Sedis pede Cassiopeae*]. For you will never find the phenomenon depart from it by three times the Sun's diameter. If therefore it had a parallax one degree greater, it would necessarily follow — when the phenomenon was in one vertical above that star — that it would be seen nearer to it by two-thirds of the former distance, and that it would not differ from it by a single solar diameter, that is, by about thirty minutes: just as is clear from what was demonstrated in the tenth and fifteenth Problems. But that such a great variation, in so tiny a distance, no one cannot discern by sight alone without any instrument. And anyone who is willing to attend to the matter by this reasoning will not only most certainly recognize that there is no such great diversity of aspect, but will find it so small and imperceptible that he will rather hesitate within himself whether — without any parallax at all — he should believe it to be a true fixed star above the orbs of all the planets: so far is it from anyone (unless captured in his eyes, or blinded by the densest darkness of ignorance) affirming it to be below the Moon.

I had decided to say nothing about determining the parallaxes of this astonishing star, or about fixing limits to them, since that does not properly belong to the history of the star. But it was recently reported to me that there had been certain men, not wholly unschooled in the mathematical arts, who had publicly testified that they had observed by demonstrative methods a parallax for this star greater than a whole degree, on which ground they concluded that its position lay beneath the lunar sphere and that it stood in the very places where comets occur. So that anyone could detect their gross and palpable error while the star was still shining, I thought it not out of place to append this simple method — so that even men ignorant of all mathematics, provided they were endowed with common sense and understanding, might be able to refute mathematics professors of this kind and to expose their ignorance. But if anyone should require a demonstration of the rule I am here handing down, let him consult our sixteenth Problem, which will, I trust, satisfy his wish in full.

By this same procedure you will be able to demonstrate most exactly the true position of a phenomenon in the heavens, and to point it out to the unschooled almost with your finger, since it always comes to perfect rest at the very intersection of the vertical with the straight line — that is, the great circle — passing through the fixed stars previously determined by the earlier technique.

Thus, since by this technique the true position of the phenomenon becomes known, while its apparent position is plain to anyone of itself, even the dullest herdsmen and sailors, once taught by this means, can very easily ascertain the distance between the two — that is, the parallax itself — how great it is and how it varies. As for these matters and other things hitherto unheard of, which can be investigated very easily by a new instrument, we shall perhaps treat them more fully hereafter, God willing, if we find that these first attempts give satisfaction. And we shall likewise treat of certain other parallaxes never before handled by anyone, known to very few or at least believed by very few: those, namely, which arise not from the deviation of our line of sight from the center of the Earth, but from the various positions of that center itself. All of this, if God favors so great an undertaking, and if the Fates spare my life, we shall set forth clearer than light.

Yet some may perhaps meanwhile accuse me of having added so few rules to the practice of all these methods I have set out by demonstration. I confess that on this point I have by no means satisfied my own wish, for I should have liked to attach to each Problem the briefest and most expeditious formulas of computation, and to set forth the other instruments especially suited to this work to the life, with pictures and a fuller explanation — had the shortness of time and my other business allowed. But I have been violently torn away at this time, dragged off as it were from these contemplations of celestial things by certain lesser human affairs, so as to attend meanwhile to my own fortunes as well, and thus I have been compelled to close my book prematurely and to lift my hand from the drawing-board. Moreover, since the chief aim of these labors of mine was that everywhere among the nations — before this rarest and most opportune occasion should vanish — the observations should be made most exactly, by which both the recent portent of God to the inhabitants of earth, and likewise the absolute, or at least the more certain, doctrine of the immense and wondrous machine of the celestial spheres might become known to mortals: since it was uncertain how long this star would shine, I judged it better, while there was yet time, to set a few snares and small nets, than to spread the amplest nets too late and in vain, when the prey had already slipped past and gone by. Hereafter, however, once the impediments of worldly affairs and of fortune have been settled and overcome, we shall, God again favoring us, return once more to our most peaceful mathematical springs. And we shall make trial of what our native Muses can accomplish in this field, and shall faithfully share with all students the secrets of Nature that, by the help of the Almighty, will be opened to us.

An Examination of What Is Contained in the Foregoing Chapter of Digges

He proposes, from the outset, a method by which — without costly means or means difficult to procure — one may readily discern whether or not some phenomenon is subject to a perceptible parallax. And indeed, if one does not aim at the highest precision, and provided the phenomenon itself is free of all proper motion, this method will be reckoned not unsuitable. For it is certain that a heavenly body set in a more sublime position, sharing with two or three fixed stars one and the same vertical circle, will therefore also trace the same path when set lower down — that is, it will by no means make a straight track with those same stars; rather, it must necessarily be rendered somewhat lower, if it is subject to any perceptible aspectual diversity arising from the Earth's semidiameter. That this, however, can be sighted by means of a single rule variously inclined, propped however on a suitable support — with at least an ocular view along the edges of the rule aimed at the stars, without any sighting-vanes [Dioptris] or other apparatus, and free of all illusion — this I would scarcely admit. For the visual ray does not proceed entirely from a single point of the eye. And even if it did, it remains unknown whether the center of vision is contained in the same plane as the edge of the rule and the stars; and there is nothing to prevent it from wavering this way and that on either side. Indeed, if there is any latitude at all, to discern that very thing with the eye held immovable is impossible; whereas with the eye shifted somewhat, the observation itself is rendered less reliable — especially since the stars, obeying the universal revolution, do not stay long beneath the same vertical. And to reach the very centers of the stars by this line of sight, and to bisect them, is a work of luck rather than of art. For this reason, when we examined Maestlin's [Michael Mästlin] manner of observing by such a method, we more fully indicated our own opinion — chiefly in the following book, in which he committed the scrutiny of the parallax of the Comet of the year 1577, in itself an extremely difficult matter, to so simple and uncertain an investigation; though he carried out this procedure not with a rule but rather with a thread stretched in a straight line.

Moreover, these things can be carried out with a thread alone, without the rule and its support, with less trouble and no more uncertainly or inconveniently. For a thread weighted with a lump of lead will of itself easily show, once it has come to rest, whether any stars at all lie together in one vertical, and will make it discernible. And afterward, with the thread stretched in another position toward those same stars, it will reveal whether they still remain in the same straight

track or not. Yet whether this observation be made with a thread or with a rule, it does not furnish the most exquisite certainty, on account of the divergence of vision and the illusion. And so, wherever the parallaxes are either nil or as small as may be, this business is left doubtful and not sufficiently ascertained.

As may likewise be seen from what Digges himself adds about the sighting [collima-

tion] of the New Star, a method instituted in this manner. For since he constantly kept the star directed in a straight track, throughout its whole revolution, with certain fixed stars — at least by the half-diameter of its own body — and does not hesitate to assert that it had not in the slightest deviated from this position in its lower place, I for my part hold that in this very half-diameter he committed an error owing to the aforesaid causes. For whether the star was carried in a higher or a lower position, it remained perpetually in the same configuration with those same fixed stars, into whose straight track it fell, and so remained perpetually central. Maestlin too, examining this same point carefully with a thread, sufficiently attests it. Hence, on this ground, the star is stripped of all parallax whatever, and for this very same reason it is rightly set back into the highest, the eighth, sphere.

Digges rightly asserts that this star could admit a parallax of no more than two scruples [minutes], provided it be granted to him that, by the half-diameter, when it was lower, it had declined from the straight line which it held with the loftier stars. For at the beginning of the star's first appearance its apparent diameter was nearly 4 minutes. This afterward gradually diminished, as we treated in chapter 7, where we discussed its visible and true magnitude — there these things are set forth in more particular detail.

But since no parallax whatever befell the foreign star with respect to the native stars, with which it was viewed in one and the same straight line throughout the whole revolution of the heaven, the wandering — and that minute wandering which Digges supposed — was easily insinuated by some illusion of the sighting, or perhaps deliberately, in that he preferred to fix the matter so as to draw the star down into the region of the planets (if indeed that seemed to him more probable). Either he chose to lay it down so, if that pleased him; or rather — what is more credible — he was driven to comply with a wavering observation; or whatever in the end it was, this pronouncement about so minute a vestige of parallax is certainly idle. Nor is it for him so arduous a task that the very quantity by which the star is remote from the Earth should be defined from it; it deserves rather to be entrusted to it as established.

The other comparison, which he appends from mere inspection with the star of Cassiopeia neighboring it — the one that is eleventh in number — affords a judgment of the New Star that stands altogether correct: namely, that the New Star in no way submitted itself to the lunar regions. For it was perfectly easy, from observation set up by means of this nearby fixed star around the vertex and the horizon, to discern that this new heavenly body was continually kept at an equal distance from it, and therefore admitted no perceptible parallax — far from enlarging it so much as to reach the regions of the Moon, which sometimes cause a parallax greater than a whole degree: just as these things are pointed out by us elsewhere too, and in chapter 6, where it is explained by numbers what distances this New Star would have had from the said eleventh star in its highest and lowest position, had it stood only near the borders of the Moon. These figures differ somewhat from the Diggesian ones here recorded, and do not exactly match them. But he, content with a broader inquiry, refrained from examining these things so subtly.

This much, however, is worth noting, namely that he himself concludes that the variation in the distance of the New Star from that fixed star neighboring it was so slight and imperceptible that he left it uncertain whether some small variation existed or whether there was absolutely none. And so he found it more probable that this new star must be raised, not merely above the nearest Moon, but above all the other planets however lofty, into the most remote sphere of the fixed stars. Had Digges held fast to this view without any hesitation whatever, and had he stood firm in this unmoved opinion about the new phenomenon, he would have granted it its genuine seat more truly and more probably. Nevertheless, since in not deviating beyond two minutes — which, certainly, without a most exactly elaborated instrument are scarcely perceptible — he did not fail in such a decision, I judge him worthy of no small praise rather than of reproach. For how enormously others have here gone astray, this third section of the present book, especially as regards the following and last chapter of it, amply makes plain.

He next excuses himself for having set forth this experiment concerning the imperceptibility of the parallax, an experiment otherwise pertaining to the history of the star itself: namely, on the ground that there were to be found certain mathematicians, not entirely unlearned, who attributed to it a parallax greater than a whole degree, dragged it beneath the Moon, and tried to persuade the common crowd that they could demonstrate this mathematically. But how silly the opinion of these men was — resting on no solid foundations — is so plainly in the open, and has so often been shown by us, that it is wearisome and shameful to repeat it. And indeed he ought to have discussed the unraveling of

the parallax of this star (if there were any) not merely on account of such gross and palpable errors (as he says) of certain men, but chiefly for this reason: that the principal hinge of the whole business in explaining this star turns upon the scrutiny of its parallax. And since the very title of his book promises the dimension of the star with respect to its distance, magnitude, and position, it was certainly not fitting to pass over the decision of the parallax. Indeed it would have been better to define this too, beyond doubt, through so many Problems — if any of them conduced to this end — and through still other reasonings besides.

As for investigating the position of the star, which he next proposes — namely by means of the intersection of the great arcs, arising from the fixed stars he had earlier named coinciding directly with the New Star — what he says is not by any means out of place. Yet here there lies hidden no small difficulty, in that those stars which he assumed, in order to indicate the position of the New Star, were not arranged crosswise and as nearly as possible at right angles by their linear track, but are disposed far too obliquely both with respect to each other and with respect to the pole of the zodiac. There is this further point, too: that each pair appointed by him did not intercept the New Star on a single line; rather, two other stars did, as we shall presently see. But seeing that by this procedure he pronounces the position of the new star to be, as it were, pointed out here with the finger and established most exactly, why, I ask, did he not undertake the labor of also defining its position according to longitude and lati-

had he first fixed the star's place with respect to the ecliptic? For that is the first requirement in determining any star's position. And if this nova always rested most perfectly (as he says) at the same intersection of the arcs drawn from the fixed stars, how could it have happened that its apparent place differed from its true one? What need was there, then, to assert that the variation of parallax could so easily have been detected here — even by sailors and farmers — when he himself admits that this parallax was almost imperceptible, scarcely amounting to a bare two minutes? Indeed, he was now claiming that the nova always remained at the same point of intersection with the fixed stars. This in fact proves that there was no diversity of aspect [parallax] at all.

And truly, even if it had been so small as to amount to a bare two minutes — which, however, we do not concede to him — the divergence between the true place and the apparent one, arising from so minute a parallax, would scarcely be apparent even to those skilled and versed in astronomy, since it is almost imperceptible; far less could the unschooled and those ignorant of the art perceive such a difference in any way. Indeed, if he had admitted a parallax of

half a degree, its implication would scarcely be discernible even to the unskilled — given that some other learned professors of mathematics, falsely attributing to the star a parallax greater even than a whole degree, did not see the absurdities that would follow from this, applied as it was, by mere inspection, to the neighboring fixed stars.

But let us make plain what has just been said: that this star did not lie individually in one straight line with the same two fixed stars that he names, but rather that two *other* pairs out of these same four that he listed should be used, if the matter is to deserve consideration. For although he asserted above (and here cites the passage) that the New Star stood in a straight line with the one on the right side of Cepheus, beneath the Girdle and Knee of Cassiopeia, and likewise with the Haunch of Cassiopeia and the other on the left shoulder of Cepheus — yet neither of these straight lines, passing through the two aforementioned fixed stars, comes even close to touching the place of the New Star, much less does it indicate that place by its intersection or exactly intercept it, as we shall now demonstrate.

The places of the aforementioned fixed stars, according to our own accurate emendation in harmony with the heavens themselves, are as follows.

NOMINA STELLARUM (Names of the Stars)	LONGIT. P.	LONGIT. M.	LATITUD O P.	LATITUD O M.
Cingulum Cephei (Girdle of Cepheus)	29	48 ♈ [Aries]	71	7
Sinistrum Brachiū Cephei (Left Arm of Cepheus)	27	30 ♈ [Aries]	62	35 ½
Flexura Cassiopeae (Bend of Cassiopeia)	8	3 ½ ♉ [Taurus]	48	46
Genu Cassiopeae (Knee of Cassiopeia)	11	57 ♉ [Taurus]	46	22

With these things laid down beforehand, let it be conceived — in the figure assigned — that A is the Pole of the Ecliptic, B the Girdle of Cepheus, D the Knee of Cassiopeia, and C the place of the New Star intercepted between them. Let there be in addition E the Haunch of Cassiopeia, G the left shoulder of Cepheus, and F the place of that nova interposed between them. It is manifest, both from the globe itself and from the adjoining drawing — which to some extent represents the arrangement of the stars — that the line drawn from B to D does not pass

through the place produced by drawing from G to E. Therefore the New Star is not to be set down in any one single place, but either at C or else near F. So its position turns out plainly to be of two different kinds, as we shall now make clear by the geometrical investigation of the triangles.

First, in triangle A D B — which concerns the two former stars together with the Pole of the Ecliptic — the first side B A is given as 18 degrees 53 minutes, from the complement of the latitude of the Girdle of Cepheus. D A is 43 degrees 38 minutes, from the complement of the latitude of the Knee of Cassiopeia. And the angle at B A D, representing the difference of longitude of the two fixed stars, is 12 degrees 9 minutes. There comes out, therefore, by triangular science, the third side B D, equal to 25 degrees 25 ½ minutes. And further, from the three known sides, the angle A D B emerges as 9 degrees 8 minutes.

Next, in triangle A D C: since the angle at D is now known — namely the same one found just above — and C D is established from our observation, through the distance of the nova from the Knee or Hock of Cassiopeia (which we noted elsewhere, among other places, in chapter 4) as 8 degrees 3 ½ minutes, and the side A D from the complement of the latitude of the same fixed star indicated before, the remaining side A C will not be hidden: 35 degrees 42 minutes, approximately, which yields the complement of the latitude of the nova. And from the three sides now given in this triangle, the angle C A D leaps out as 2 degrees 11 minutes. This, subtracted from the longitude of the star in the Knee of Pegasus — which by our restitution was at that time 11 degrees 57 minutes γ [Taurus] — gives the longitude of the nova as 9 degrees 46 minutes γ [Taurus]. Its latitude, found before from the complement, comes out as 54 degrees 18 minutes.

Furthermore, by an entirely similar method we shall track down the place of the nova from the two remaining fixed stars positioned at G and E. And since here, in triangle E G A, there is given first...

G A from the complement of the latitude. The star in the left arm of Cepheus, which is the eighth in number, is 27 degrees 24 ½ minutes; and E A, from the complement of the Haunch or Bend of Cassiopeia, is 41 degrees 14 minutes. And the angle comprehended by these two sides, G A E, through the difference of longitude of the two stars, is 10 degrees 33 ½ minutes. The third side, E G, will come out as 15 degrees 0 ½ minutes. And the angle A E G is 19 degrees 0 ⅔ minutes. Hence in the other triangle F A E — to which the said angle also belongs — from the known side F E, set out by an observation in the place we have mentioned, of 5 degrees 2 minutes, and the other side previously made plain, the third side F A will not be unknown: 36 degrees 30 minutes, the complement of the

latitude assigned to the nova. And with three sides now made plain, the angle F A E will not escape us: 2 degrees 45 minutes, which, taken from the longitude of the star in the Bend of Cassiopeia, yields the longitude of the nova as 5 degrees 18 minutes $\propto$ [Taurus]. Its latitude, from the complement found before, will be 53 degrees 30 minutes.

And in this way, the nova having been found twice over from the stars that Diggeseus [Thomas Digges] alleges, it turns out manifestly that these places by no means agree with one another, nor do they even coincide in close proximity. That this may appear more clearly, we shall set the two places, found in both ways, before the eyes themselves.

Locus Novae Stellae hoc
pacto inventus ex (The
place of the New Star
found in this way from) —

NOMINA STELLARUM (Names of the Stars)	LONGIT. P.	LONGIT. M.	LATITU. P.	LATITU. M.
Cingulo Cephei & Genu Cassiopeae (Girdle of Cepheus & Knee of Cassiopeia)	9	46 $\propto$ [Taurus]	54	18
Coxa vel Flexura Cassiopeae (Haunch or Bend of Cassiopeia)	5	18	53	30
Differentia utriusq; (Difference between the two)	4	22	0	48

Since, therefore, a discrepancy of 4 $\frac{1}{3}$ degrees falls between them as to longitude, and of one degree less a twelfth [i.e., about 48'] as to latitude — by what method, I ask, could it have come about that the new star should be located at the meeting of the lines drawn from these fixed stars? From which it is also clear that these lines did not cross each other in an intersection, but were set apart from one another at a fair interval, and that they did not intercept the nova in any way at all. For this reason its places, derived in this twofold manner, depart so greatly from the true and genuine position of the star itself, which we demonstrated exactly in chapter 5.

But by drawing through the other two pairs of fixed stars in turn — namely from the Girdle of Cepheus to the Bend of Cassiopeia, and from the left arm of Cepheus to the Knee of Cassiopeia — we shall test whether, by intersecting one another, they contain the New Star in a fixed and assigned place.

Let it therefore be assumed that, in the figure set beside this, A is the Pole of the Ecliptic, B the star in the Girdle of Cepheus (which is the third in number), C the one in the left arm of the same (the eighth in number), D the New Star, E the Bend of Cassiopeia, and F the Knee of the same. First, in triangle B A E, the sides B A — through the complement of the Girdle of Cepheus, 18 degrees 53 minutes — are known, and E A from the complement of the Bend of Cassiopeia, 41 degrees 14 minutes. And the angle B A E, intercepted by these, from the difference of longitude of both fixed stars, is 8 degrees 15 ½ minutes. Therefore the third side B E is made plain as 22 degrees 41 minutes, representing the distance of the fixed stars. From the three sides now known, then, the angle A E B will emerge as 6 degrees 55 ½ minutes, which in the other triangle A E D will supply the angle at E together with one other.

Hence, from the two sides there enclosing it, A E (through the complement of the latitude of the Bend of Cassiopeia, 41 degrees 14 minutes) and E D (from the distance of the nova from the Bend, which we have accurately ascertained as 5 degrees 2 minutes), the third side A D will come out, the complement of the latitude of the nova, equal to 36 degrees 14 ½ minutes. And from the three sides now once more made plain, the angle D A E will come out openly, marking the difference of longitude between the nova and the Bend, 1 degree 1 ½ minutes; and when this is subtracted from the longitude of the Bend, the longitude of the nova results as 7 degrees 2 minutes ✕ [Taurus], approximately; its latitude, from the complement made plain before, being 53 degrees 45 ½ minutes.

And in assigning here to the New Star a place which we have confirmed so many times by our own observation, scarcely eight scruples [minutes] intervene by such an alignment, an excess which is easily committed as to longitude. As to latitude, however, it agrees with ours almost to the very minute, the surplus here being at most half a scruple, which is altogether imperceptible.

Again, we shall make trial as to where this nova falls from the two remaining stars. Therefore, in triangle C A F, with the side C A first known — 27 degrees 24 ½ minutes, the complement of the latitude of the eighth star of Cepheus providing it — and F A, from the similar complement of the Knee of Cassiopeia, 43 degrees 38 minutes; and with one angle intercepted by these, from the difference of longitude of the two stars, known as C A F, 14 degrees 27 minutes, the side C F will

be ascertained, the distance of those stars from one another, 18 degrees 10 ½ minutes. And the angle A F C turns out as 21 degrees 37 minutes, approximately. This next, in triangle A F D, establishes the angle at F. And with both enclosing sides known — F A, 43 degrees 38 minutes, from the complement of the latitude of the Knee of Cassiopeia, and D F, the distance of the nova from the same...

Diagram. A spherical-triangle construction in the form of a pointed (almond/vesica) figure, with apex A at the top representing the Pole of the Ecliptic. Several great-circle arcs descend from A toward the lower rim, crossing one another. The labelled points along the arcs, from upper-left curving down to the lower-right, are positioned as follows:

- A (apex, top): Pole of the Ecliptic
- B (upper interior): Girdle of Cepheus
- G (left side, below B): left shoulder of Cepheus
- F (center, below B): place of the nova (between G and E)
- C (center-right): place of the nova (between B and D)
- D (lower right): Knee of Cassiopeia
- E (lower right, below C): Haunch of Cassiopeia

The two crossing arcs (B–D and G–E) are shown not to coincide at a single point, illustrating the two distinct derived positions C and F.

Diagram. A second pointed (almond/vesica) spherical-triangle construction with apex A at the top (the Pole of the Ecliptic). Arcs descend from A, and a transverse line C–F crosses them lower down. The labelled points are:

- A (apex, top): Pole of the Ecliptic
- B (interior, upper-center): star in the Girdle of Cepheus (third in number)
- C (left, on the transverse line): star in the left arm of Cepheus (eighth in number)
- D (center, near the crossing): the New Star
- E (lower center, below D): Bend of Cassiopeia
- F (right end of the transverse line): Knee of Cassiopeia

The transverse line runs from C (left) through D to F (right); arcs from A pass through B and down to E, the construction showing how the two arc-pairs are tested for whether their intersection contains the nova.

the side found by us "in the Knee" is 8°31½'; the remaining side AD — which will not escape us — is, by the complement of the assigned latitude of the New Star,

$36^{\circ}14\frac{1}{2}'$; and the angle DAF besides, arising in the same triangle, comes to about $5^{\circ}1'$. Once this is subtracted from the longitude of the Knee of Cassiopeia, the longitude of the New Star will be marked at $6^{\circ}56'$ in Taurus [♉], just as we set out to find.

And from this latter investigation it is plainly clear that the position of the New Star agrees as nearly as possible with the one we indicated earlier in chapter 5 — so much so that it is almost identical, the two results differing only here by two scruples [seconds, *scrupuli*] in longitude, while in latitude they coincide to the very same minute. This small difference in longitude must be reckoned of no consequence in a matter of this kind.

Therefore, since the placement of the New Star — found by both methods — converges so closely on one and the same spot, and agrees with our own determination, there can be no doubt that the transverse line of the lines intercepting the New Star must be derived from those Fixed Stars, and the procedure must be arranged in the way we have just now carried it out, rather than in the manner that Digges himself, perhaps through a certain carelessness, prescribed.

And if we set a limit to both longitudes that we investigated in turn — taking the mean of the two — the longitude of the New Star will fall at $6^{\circ}58\frac{1}{2}'$ in Taurus [♉]. This does not exceed our determination of the Star's position by more than 4 or at most 5 scruples [seconds], a quantity that even among the learned is reckoned of scarcely any consequence, especially from an inference of this sort. The latitude in both cases agrees thoroughly with ours, and as it were coincides with it. And these were the things we proposed to demonstrate that needed to be sought out of Digges's pronouncement concerning the place of the New Star.

But even though, without the distances of the New Star from the Fixed Stars employed here, the place of this body — which the intersection at D indicates — could, in accordance with our Observations and assumption, have been thoroughly investigated by nearly the same method as we used above in the account of the resolution of Maestlin's [Maestlin] working, nevertheless, since that method is entangled with many more wrappings and ambiguities, and is not so easily applied here and there, and does not resolve into a practical computation with numbers — because in this Diggesian arrangement the tracing of the Stars is disposed too obliquely with respect to its own Ecliptic and Pole; and because that tracing, crossing alternately from one side to the other, does not do this directly enough, but by an excessive obliquity renders the investigation of the point where the crossing occurs difficult to find by numbers — for these

reasons this rough and thorny path was set aside, and we judged it better to proceed by the other, more level and safer route, even though some of the Stars distant from the New one had to be borrowed here from our own observations. For variety in itself is not unwelcome, and the procedures of demonstrations, set up in one way and another, instruct learners more richly.

And so let it suffice that, from Digges's very contrary arguments — though inverted in another way — we have investigated the place of the New Star (which he himself passed over too carelessly) and reconciled it with our own determination, just as we intended.

He promises afterward a certain new Instrument, by means of which Parallaxes and other things of this kind, hitherto unheard of, may be investigated most easily. But what this Instrument is to be — by whose sole help Parallaxes might come to be measured without any demonstration or computation — I for my part do not see; and I have no hesitation in affirming, after weighing the whole matter carefully enough, that scarcely anything of the sort can be furnished by any subtlety of invention or workmanship. But if Digges, or anyone else, is confident that he can supply it, let him by all means bring such an instrument forward into the open, and let it be tested in operation. For here it is worth not so much speaking as rather doing.

Nor indeed will he discover, even by this Instrument that he promises — or by any other, fashioned in whatever way at last — nor will he demonstrate by any irrefutable contrivances that there are certain Parallaxes which arise not from the Semidiameter of the Earth but from a change of its Center. For the Copernican speculation about the annual motion of the Earth, which gave him the occasion for putting this forward, will never be found to hold firm in the truth of the matter on the strength of any observation, however accurately explored.

The Mathematician of the Most Illustrious Prince Landgrave, Christoph Rothmann [Christoph Rothmann], did indeed report to me that he had sometimes noticed the altitude of the Pole presenting itself in summer one or another minute differently than in winter; and that at one time rather than another certain Fixed Stars — especially those separated by a large interval — were found at slightly different intervals from one another, which also underwent a variation of about two minutes. From this he supposed it could be rendered probable that the Earth does not perpetually occupy the unmoved center of the universe. But that minute difference, scarcely perceptible in itself, could easily creep in on account of one or another disposition of the Instrument, of alteration, and also of the diversity of the air, and of collimations not everywhere alike — if equal care

were not applied throughout. We, certainly, whether in winter or in summer, have scrutinized the altitude of the Pole and the distances of whatever Fixed Stars by means of our Instruments — most of which divide off not merely single Minutes but even some fraction of them most finely — and we have found absolutely no such diversity in these (provided that an equal serenity of the Air shone everywhere, and that Refractions, wherever they might have crept in, were guarded against), our exploration being applied frequently and diligently.

Copernicus, to be sure, demonstrated not inelegantly the Parallaxes arising from the motion of the annual Orb as observable in the five Planets, by means of the assumed motion of the Earth, so as to show quite aptly that this supplies the office of all the Epicycles. Hence too he named this inequality of motion — which the ancients supposed to be produced by Epicycles — the "Parallax of the Orb" (namely, of the annual one). But since this apparent inequality can be saved otherwise than through Epicycles, even with the Earth at rest, what need is there to assume, incompetently and as a thing that cannot of itself deserve a place, what cannot be asserted for truth — so that, however much...

a true induction may be built upon a false hypothesis? From the Planets, therefore, the annual mobility of the Earth will not be sufficiently proved, since those diversities which by means of it square with their appearances obtain their origin elsewhere. But if some wandering displacement [*divagatio*] could be discerned among the Fixed Stars within the space of a year, then it would indeed be persuasive that this came about on account of the motion of the Earth on which we dwell. Yet since, as we have said, no such alteration is in fact discerned among the Fixed Stars, the other conclusion is drawn from this in vain.

Copernicus, lest he should run up against this absurdity and impute to the Fixed Stars some apparent instability arising from the annual revolution of the Earth, chose rather to admit something else no less unsound and incredible: namely, that so great a capacity is comprised between highest Saturn and the Sphere of the Fixed Stars that the annual Orb of the Earth, in comparison with it, is rendered imperceptible on account of that excessive interval, and wholly vanishes away. On this matter we shall treat elsewhere — how far beyond all belief it is, and how great the absurdities that follow this position.

Let Digges, then, or anyone else, construct Astronomical Instruments of whatever sort and of whatever size he pleases. The more perfect and exact they are, the less will he be able to make good his claim that the Earth admits of any motion, and that any Parallaxes arise from this (apart from those which Copernicus, as has been said, accommodated to the Planets, which take their occasion elsewhere).

In conclusion, finally, he brings forward this point — that he has attached no Practice or Operations to his Problems on account of other distractions and occupations — as an excuse. But for my part I do not so much linger over the fact that he did not himself resolve the Problems into numbers by worked examples (for that is not difficult for anyone with intelligence in the matter) as over the fact that nowhere concerning the New Star — whose Appearances he had principally undertaken to explain — does he bring forward any observations or any data given for the quadrature of his Problems, nor put them to use. This is what I miss in him. For Theory alone is not to be reckoned as satisfying the completion of Science, unless a Practice consonant with it be applied. But leaving these things aside, we shall now briefly survey and examine by inspection what, after all, Digges puts forward in the very Conclusion of his Work.

Finally, in the Conclusion of the whole little book, he weighs the Problems he had proposed for eliciting Parallaxes; and since they are not all equally suited to practice and demonstrable by Geometry, he rejects some of them outright (so far as concerns their use), and prefers others to the rest. Here Digges rightly admits that many things capable of being reasoned out well enough mathematically are offered, which nevertheless, if they are carried over to the experience of the senses, frustrate the effort. He then brings forward three causes why the Practice of Parallaxes is rather intricate, less expeditious, and not free of all doubt. The first: from the excessive abundance and variety of the requisites, since when any single one is lacking, the rest are thrown into confusion. The second: on account of two or three observations being given simultaneously with difficulty at the same moment of time — observations which also cannot be repeated quickly enough, as is needful. The third: on account of the Instrument and its subdivision not being of an aptly just...

magnitude. From these occasions, I say, very many obstacles creep in, so that this subtle investigation of Parallaxes cannot be practiced to the desired end without any suspicion of error — and he asserted this rightly and deservedly. Although there are also many more things that complicate this business, which we shall not now treat, since they can be thoroughly grasped only by those who have diligently handled Astronomy mechanically and in the heavens themselves, and have been taught by long experience. It is certain, too, that those methods of observing which require the moments of time to be precisely known are not a little entangled with ambiguity — just as neither are those which are founded on Azimuths sufficiently safe, on account of their difficult and too-slippery determination, if (as is also required) the matter is to be carried out with great precision. And if the altitudes are to be taken at the same time, an Instrument is

required that is most exactly and in every part disposed to the line, made firm, and so conformed, and to be administered together with no sluggish readiness of collimation. Such things are surely not everywhere ready to hand. Moreover, even where the matter can be managed by altitudes alone, it will by no means be possible to take them off with that precision which is fitting by the help of the Astronomical Radius [Radius Astronomicus], as Digges supposes. For the Radius is properly suited to taking the distances of the Stars; and if it has to be applied to scrutinizing altitudes, it will perform this in a somewhat constrained way, and not so readily and surely. Indeed, it is not even granted to examine the distances themselves within one or another Scruple [second] without suspicion of error, this being a hindrance besides. As we have already shown above from those very observations made by Digges with the Radius among the neighboring Stars of Cassiopeia and the intervals of the New Star. But in determining distances, a hallucination [error] of one or another Minute leaves no room for excuse in the resolving of Parallaxes — especially where those distances have not been altogether evident — on account of the far greater deviation it produces in them.

From all of which it is plainly clear that scarcely one or another of those methods which Digges brings forward in his Problems satisfies the most subtle and universal investigation of Parallax with respect to Practice.

But among the Problems which he proposes for scrutinizing the Parallax of a Phenomenon, he judged the first four — from the tenth up to the fourteenth — to be less accommodated to use, preferring among them, however, the first two, and especially the tenth. All the rest, since they rest chiefly on distances which are more readily observable, and the other requisites of which are not entangled with too many difficulties, he was of the opinion that they stand well enough, and can be applied to use commodiously and without error.

But I, surveying all his Problems, shall briefly indicate what I think of each one — and of certain ones somewhat otherwise — namely, whether or not they are fit for practice.

The Tenth Problem, which is the very first of all to scrutinize Parallaxes, is in my judgment, beyond the rest, most aptly useful for the purpose of eliciting the Parallax of this New Star...

It is useful. For the greatest and least distances of the star from the zenith, together with the latitude of the place, could be read off by a quadrant of suitable size and graduation without difficulty in the observation. Nor does it pose any obstacle that the position of the meridian — at which these altitudes are

measured — should be unknown to within half, or even a whole, degree of horizontal azimuth. Its correct determination presents little difficulty, since the altitudes here do not vary so abruptly, as Digges [Thomas Digges] alleges, but rather quite slowly. Thus, for capturing them properly by these means, there is ample time and opportunity.

This method, therefore, is the simplest and safest of them all; yet Digges did not put it into practice on the example of the new star. Perhaps this was because his radius — apparently the only instrument he used — was not so precisely calibrated as the task required, and a measurement of altitudes was not available to him. The most illustrious prince, the Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel], proceeding by this method, attributed to the star a parallax of 3 minutes — although for my part, from his very own observations, once the pole-altitude that his instrument then yielded was applied, I gathered absolutely none, as is evident from what was said above. Indeed, from the observations of Consul Hainzel [Johann Baptist Hainzel], made with our large quadrant set up near Augsburg in Bavaria, I demonstrate fully in chapter 6 that by such a method no parallax whatever resulted for the star.

The *Eleventh Problem*, which from two given altitudes of the star in the same azimuth, together with the pole-altitude, seeks the parallaxes, can also in a way be carried into practice — provided the determination of the same azimuth and of the altitudes is set up without error. It has, however, less to recommend it than the preceding one, in that the altitudes here vary more quickly; and the indications of the parallaxes are not, on this account, evident and readily observable, as they are on the meridian itself, since the difference of altitude here turns out to be smaller.

The *Twelfth* could in some measure earn its place, if the positions of the fixed stars congruent with the sky itself were not unknown — and at transit across the meridian it would be quite well able to carry everything through.

The *Thirteenth*, since it presupposes that azimuths and altitudes are to be taken in differing ways, demands too many and too slippery data.

The *Fourteenth*, which seeks the parallax from the altitude of the star in the most remote azimuth, would not be wholly useless if it were carried out carefully with a suitable instrument. It has this difficulty in particular: that the phenomenon does not suddenly, but only gradually, vary its greatest azimuthal distance from the meridian. This indeed could pose no obstacle, were the altitudes meanwhile

not to undergo very much alteration — so much so that it can scarcely be discerned at which moment the truer one is to be captured.

And these were the earlier Problems, which Digges for the most part rejected; the following ones, however, he approved as sufficiently suitable for use. About these too we shall now take a look.

The *Sixteenth*, although it proceeds from the distances of the star alone, taken in differing ways from the fixed stars, and is on that account more safely practiced — nevertheless, in that it requires the vertical [circle] of the phenomenon through those same fixed stars to be drawn at right angles in the second observation, just as in the first, it is not set up with sufficient precision and convenience, and it demands many of the very same requisites, which are not conveniently met. It can, nonetheless, with careful diligence applied, be adapted to use, especially in the more considerable parallaxes.

The *Seventeenth* requires data not everywhere available, presenting themselves all alike — more than is just, and which moreover, with regard to azimuths equally remote from the meridian on both sides, together with the distances to be taken simultaneously, are not as easily, surely, and quickly worked out as the task demands. To this is added the fact that, unless the parallax is of a quite perceptible magnitude, it is scarcely grasped by this reasoning, which does not much distinguish its variation.

The *Eighteenth* is entangled with more presuppositions than is just, which are not easily offered free of every suspicion of error.

The *Nineteenth* likewise demands excessive requisites, not everywhere available, or sufficiently quick and safe to observe.

The *Twentieth* too is liable to the same impediments: that is, if two distances and three differing altitudes must be taken simultaneously. This is achieved at the same instant only with difficulty. To this is added the fact — here as in the preceding several Problems — that no sufficiently evident discrimination of the parallaxes is given. And therefore, when those [parallaxes] are in themselves minute, they scarcely lie open, by this kind of reasoning, to sure observation and demonstration — the tenth Problem alone, which exhibits the greatest magnitude and difference of these, that can be obtained, being exempt from this drawback.

The *Twenty-first* and last Problem, finally, divides the now-known parallax with respect to the ecliptic and the equator. This in itself stands rightly, although it

would not be difficult to accomplish the same by an easier and less involved method.

This shall be our opinion concerning Digges's Problems; let others judge of them as each sees fit. If the proper procedure is set up mechanically, it will at last be established what in these matters can be performed without error, and what cannot — and it will be made plain that we have offered no unjust verdict upon them.

Finally, Regiomontanus's Problem he [Digges] adapted quite skillfully and aptly to this new star — although he himself, for several good reasons, rejects its use in this conclusion. That Regiomontanus's [Regiomontanus's] approach, by which he taught how to investigate parallaxes, is too slippery and most apt to lead astray, is to me beyond all doubt. For how very difficult it is to capture azimuths together with altitudes free of any suspicion of error, and the moments of time — which here, even in the very

seconds of arc, are required to be marked precisely — cannot be readily discerned, unless aids are employed, hitherto unknown to most, which I myself learned long ago and Experience has often taught. In the following book, when I examine the comet of the year 1577 according to these arguments of Regiomontanus for extracting the parallaxes, I demonstrate by the examples themselves the impediments by which the whole matter is prevented from being carried through to the desired end; and I then prove this further from the observations of the Landgrave [Wilhelm IV, Landgrave of Hesse-Kassel]. If they were to admit a parallax of 7 or 8 degrees for the comet, as Digges supposed, I would certainly grant to them that this method of Regiomontanus — and even certain of his own among them — could be applied to this investigation not entirely without use, except that the impediments of proper motion, which in comets are not slight, would in no way be guarded against.

But since all comets are necessarily generated above the Moon — so much so that anyone who has read through our later volumes, which treat this subject at length, and has weighed them in a just balance, and has nevertheless presumed to deny the same, ought deservedly to be reckoned a poor mathematician, if not utterly destitute of common sense and a hater of truth — and since the parallaxes that occur in the heavens beyond the Moon scarcely reach a single degree, and comets so rarely turn out so low that none of those carefully observed by us has exceeded a third part of a degree, even close to the horizon itself; and since some of them too have been found wholly free of parallax with regard to every perceptible quantity: certainly neither Regiomontanus's nor Digges's [methods] —

however acute and subtle the speculations, and however manifold the devices for searching out the parallaxes — deserve any place at all in those very comets; the proper motion of the comets, moreover (of which I have spoken), frequently and quite evidently eluding the parallaxes, and frustrating every reasoning of this kind.

If all that has been said before should be able to raise a doubt in anyone, let a test be undertaken on the planets, or even on the fixed stars themselves, which are destitute of all parallax; and I do not doubt that, whoever has made use of these methods (which I have judged less serviceable), he will end by deducing the matter into the absurd and unfitting — or else, with the greatest care applied, only by chance, rather than by sure inference, will he have hit the mark aimed at.

Finally, he [Digges] adds yet another occasion for error, especially in unraveling minute parallaxes, which the arithmetical computation itself involves, by reason of tables of sines that are not everywhere most exact: especially if more frequent multiplications and divisions, and also extractions of roots, are to be employed. For then it easily happens, through so many windings and turns of the calculation, that when the operation has been brought to its conclusion, one minute or another drops out, and prevents the parallax from being investigated with sufficient subtlety. Since all this has been prudently and aptly brought forward by Digges, and explained besides at greater length, I am unwilling to add anything further on it here, with this one caution only: that in operations of this sort, that procedure be chosen above the rest which is least subject to the entanglements of repeated calculation, and which has least need of the tables of sines — especially toward the end. For thus the way to the very center of truth will be aimed at more simply and exactly, without intricate labyrinths, and it will be reached.

Lastly, at length he renews his exhortation that whether the Copernican hypotheses are sound or not — whether their examination might be carried out by means of this new star — should be inquired into. But how vainly he thought this, and how this star has contributed nothing at all to that purpose, and what absurdities follow from such a presumption, since this has already been sufficiently shown by us earlier when treating the same matter, I am unwilling to repeat the same things here at greater length, lest I seem to be tediously droning out the same old song.

But as for the admonition and exhortation he appends, by way of a finishing flourish, to the students of this art — which I judge entirely necessary and useful, especially given how greatly this most excellent of sciences is neglected, or at any

rate handled with less accuracy than it deserves — I would wish that at least Digges himself, and others too, eminent in England and elsewhere everywhere, mathematicians who lead the way for others not only in words but also by their own heroic deeds, and who rouse the more sluggish, would not refrain from offering them an example for imitation (entangled though they perhaps are, more than is fitting, in the distracting cares of worldly affairs). But although such things might indeed be wished for by many, and have long been hoped for, they are not so easily to be expected. We ourselves, for our part, descend into this arena not so much by the urgings and instigations [of others] as by the deeds and the very facts; and so far as in us lies, we shall not shrink from putting our hand to this Work (the supreme heavenly Craftsman favoring us). And here we conclude our consideration of Digges's writing, together with its author himself.

JOHN DEE, ENGLISHMAN [Iohannes Dee Anglus]

After this little book of Digges's, there follows a certain short treatise, published in print, by that most excellent and renowned man, Dr. John Dee [John Dee] of London, which he calls the kernel of parallactic commentary and practice. He is indeed learned and exceedingly ingenious, and his work contributes not a little to unraveling and distinguishing the differences of parallaxes from one another. But since, concerning this new star — with which we are here principally concerned — he includes no observations, and no deductions into practice according to this kernel, but only promises in his preface that he will at some point hereafter pursue such a thing (which, however, whether it has been accomplished up to now, I have no knowledge of), I do not think it worth the trouble to add anything to the theorems of his parallactic kernel itself, which are everywhere sufficiently fortified by the author himself with geometrical demonstrations and competently explained. It would be desirable, if that most excellent man Dee obtained any accurate observations on this star, that they should be made public. For I do not doubt that he, being a man endowed with a penetrating mind and especial diligence and

and he treats with equal care the philosophical subtleties involved, devoting solid diligence as well to the appearances of this star.

Christoph Rothmann [Christoph Rothmann], mathematician to the most illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV of Hesse-Kassel], reported the following to me. Not long ago, when by his Prince's command he had come to inspect my astronomical instruments, he learned among other things — from a familiar conversation with the said John Dee, when Dee passed through Kassel on his way home — that Dee was entirely of this opinion: that this star was

a recent one, contained indeed within the immense capacity of the aethereal world, yet not in one fixed place. Rather, with respect to its distance from the Earth, it had not remained perpetually in the same position, but, climbing little by little along a straight line from a lower position to a higher one, it had withdrawn itself.

This opinion, although it did not seem objectionable to the said most illustrious Prince, nor indeed to Cornelius Gemma [Cornelius Gemma], was in fact — with all respect both to these men and to Dee himself (as I have said) — in no way consistent with this star. For apart from the fact that such a kindling and descent, and such a motion, is imperfect, and therefore cannot rightly be attributed to celestial bodies, which are perpetually accustomed only to a circular, absolute, and regular rotation, there is this further point: if this star at some time had a lower position, it must have had either some parallax or none. If some parallax, then beyond any doubt — by these very wonders — it would have had to be shown, as it gradually extended itself, that it was being displayed; but if none, then certainly its ascent could not be proved by the absence of parallaxes, for it would lie beyond all the senses and would shut off every avenue of demonstration. And since knowledge proceeds from the senses, when these fail it can scarcely be granted any place in physics — unless someone is willing to accept conjectures in place of sound knowledge.

But since no parallax whatever was ever present to this phenomenon — as I demonstrated in many ways and beyond every doubt in Chapter 6, and as, if anything has been brought forward differently by others, it must of necessity have arisen from a fault of the instruments and of the sighting — it is in no way probable that this star removed itself from the Earth along a straight line; for the very nature of the heavens, as I have said, is opposed to it. On this matter too I dealt with several points when I examined the opinions of Cornelius Gemma. And even if there were nothing else that directly proved that the matter is in no way so, certainly the absurdity that follows from it — which I mentioned in Chapter 7 — is itself sufficient proof. For it would have been necessary for this star to have been moved off more than 300,000 [Margin / inline figure: 300000] semidiameters of the Earth before, while keeping the same magnitude that it had had when set very nearly above Saturn, it would, by mere elongation from the eye, appear like a little star of the sixth magnitude. Indeed it would have had to surpass, by its ascent, more than [several? — "*plùs quàm vices spatium illud*," more than several times over] that space which lay between the Earth and its first position; and so it would render the vastness of the heaven above Saturn greater, by so incredible an interval, than the reckoning

than the proportion by which the distance from this [point] — or even from somewhat above it — extends all the way down to the Earth. But who could concede so excessive an asymmetry of the world to the senses? And what would happen if it were raised still higher, until it altogether escaped every faculty of the eyes (to which a star of the sixth magnitude is still barely subject)? Truly I do not see how those who have tried to excuse the diminution of this star by its higher recession from our view can extricate themselves from this absurdity — unless perhaps they wish to say that, together with its ascent, it gradually diminished of itself. This is easier to assert than to prove. And even if it be granted, since the natural motion of the heavens — which, as I have said, is perpetually circular — resists it, why should it not also be allowed that it remained perpetually in the same place, not climbing higher, but gradually dissolving away? But if anyone should further maintain that this star, arising apart from the natural order, was not bound to the customary motions of the heavenly bodies — certainly, since it obeyed the universal revolution and persisted in one place like the fixed stars, no one with sound reasoning will lend credence to the claim that it admitted anything else beyond the laws of the fixed stars.

But now let me set an end to the inquiry into the English speculations on these matters, since in Scotland and in the rest of that most extensive and flourishing northern part of the British Isle, no one — so far as I know — has published anything about this remarkable star, even though there too men gifted with sharp mathematical talent are not lacking. Having therefore left all of Britain behind, I shall turn to the Germans, who are nearer to us, and I shall now strive to bring forward and weigh further whatever others, besides those enumerated above, have written about this star.

Elias Camerarius, Professor of Mathematics in the Academy of Frankfurt on the Oder.

So then, as we now return from England and cross over once more from there into Germany, the first to meet us toward its northern region — the part nearest to us — is the most learned mathematician of the School of Frankfurt on the Oder, Elias Camerarius. His complete treatise on this new star, as it was published in print, I have not yet had the chance to see; but the most distinguished lord Dr. Thaddaeus Hagecius [Tadeáš Hájek] shared with me in manuscript the principal part of it, the part dealing with the observations and the position of the star — as well as several other descriptions of this star, though I already had most of them ready to hand. Therefore I shall here set down, just as Thaddaeus had excerpted

them, those observations from the said Frankfurt professor that chiefly bear on this star, which had been recorded on paper and sent to me — since in themselves they are not so very numerous, and are perhaps not everywhere easy to find.

From the writing of Elias Camerarius on this new star, certain principal matters noted down.

At the beginning of November of the year 1572, in the evening, around the 10th hour near the meridian, a new star appeared, which — like the Lyre and the Goat [Capella] — neither rises nor sets. It appeared from the outset without a tail, in the form of a star of the first magnitude; and in our view it surpassed Jupiter in size, though its body yielded to Venus. It was not a fixed star of the first magnitude, much less a planet. The latitude of this star was 54 minutes [P. = puncta/minutes] north; the longitude was about 7 minutes in Taurus [γ].

There follow observations made by the same man and reduced to use.

On the 23rd and the following days of the month of November, year 1572, in the evening, the new star stood at a distance from the zenith of $9^{\circ} 30'$ on the meridian circle. But on the morning of the following day, on the same meridian, it declined from the zenith by $65^{\circ} 52'$; the interval between the two distances was $56^{\circ} 22'$.

The elevation of the pole at Frankfurt, by observation, is $52^{\circ} 24'$. Now if from $9^{\circ} 30'$ I subtract the complement of the elevation of the pole, namely $37^{\circ} 36'$, there remain $28^{\circ} 6'$ for the distance of the observed place from the pole of the world toward the zenith. But if $9^{\circ} 30'$ be added to the elevation of the pole, the arc of northern declination from the equator will be established as $61^{\circ} 54'$.

Next, if from the complement of the maximum declination of the observed [star], $24^{\circ} 8'$, I subtract the elevation of the pole, there remains the distance of the new star, observed from the pole of the world, below the pole, $28^{\circ} 16'$. Or if to $24^{\circ} 8'$ be added the complement of the elevation of the pole, there come out $61^{\circ} 44'$ as the declination from the equator, below the pole of the world. Therefore, the smaller distance being subtracted above the pole, $28^{\circ} 6'$, from the larger below the pole, $28^{\circ} 16'$, there remains a parallax of $10'$ [scrup.]. By the same diversity of aspect, likewise, there comes out — the smaller declination from the equator, $61^{\circ} 44'$, being subtracted from the larger, $61^{\circ} 54'$ — for which there are 2 seconds [scrupula], namely the parallax from the zenith, [reckoned] at $9^{\circ} 30'$. If they be added, a true parallax of $12'$ is established.

In the year 1573, on the 5th, 6th, 7th, and 8th of January, after sunset, the least distance from the zenith was found to be $9^{\circ} 33'$. But in the morning the same distance from the zenith was $65^{\circ} 43'$. Therefore the parallax was $4' 30''$ [4 minutes and 30 seconds] of the first [minutes]: at which time it seemed to be decreasing.

On the 7th of April and the following days, after 10 in the evening, the greatest distance from the zenith was $65^{\circ} 40'$. The least distance, on account of the approach of the Sun, could not be obtained.

On the 7th of August and some preceding and following days, after the 1st hour, the least distance from the zenith was found to be $9^{\circ} 34'$.

This star did not decrease in body, but rather rose higher into the firmament, since at no time did it make any parallax. Therefore the opinions of those who suppose that such portents have their abode in the elementary region cannot be saved by the example of this star.

And although they propose, with plausible arguments, that comets and other portents are generated from dry and hot exhalations, and rolled about in the highest part of the air around the Earth — yet such speculations do not confirm them by demonstrations. Aristotle indeed, in Book 1 of the *Meteorology*, chapters 8 and 9, makes mention of four principal comets, which shone in the years 410

and 341 before the birth of Christ, when Euclid [Eucleo — i.e. Euclides], Aristaeus, and Nicomachus [Nicomachus] were ruling at Athens [recte: when these men flourished at Athens]; but he does not prove by demonstrations that they existed in the elementary region.

That this star did not have its place in the elementary region can be shown even by mere ocular inspection, without instruments. For it is known to all who have so much as tasted the principles of astronomy that, when the Moon declines from the zenith by 50° , then the arc of the diversity of aspect [parallax] amounts in latitude to $1^{\circ} 7'$. The diameter of the Moon, moreover, commonly amounts to $30'$, and it appears to us, with respect to our view, of a common foot. The arc of the diversity of aspect, then, will take, with respect to our view, the interval between the apparent and the true place of one ell [ulnam]. But the distance of some place in the elementary region, 26 semidiameters from the center of the world, yields 2° of diversity of aspect; a distance of 20 semidiameters, $2^{\circ} 30'$; while a distance of 15 semidiameters takes an arc of diversity of aspect of 3° .

If, then, this star were elevated only 26 semidiameters of the Earth from the center of the world, the arc of its parallax would be of two ells. If 20

semidiameters, the diversity of aspect would contain two ells with a half; and if it stood 15 semidiameters off from here, it would constitute a parallax of three ells. And from this it would necessarily follow that this new star, in the greater declination toward the north, would fall below the eleventh star of Cassiopeia by the space of two ells. But it is established with certainty that, the new star being toward the north in its greatest declination from the zenith at an interval of 40[?] 45[?], it has always stood 50' below the eleventh star. The new star, moreover, retains even now toward the north the same interval of about 50' that it has near the zenith on the meridian.

From this common ocular demonstration, therefore, it likewise follows that this star cannot have its place in the elementary region — a conclusion which young men of moderate training in the science of astronomy can easily understand.

And so that I may also show in which dodecatemorion [twelfth-part] of the zodiac this star lies, with respect to longitude and latitude, I add the calculation of this matter as well, in a few words.

Since the tables do not correspond to the true places of the fixed stars in the heaven — and therefore I could not gather the true longitude and latitude of this star in the dodecatemorion of the zodiac by collation with the fixed stars — I procured for myself two clocks accurate enough, each having twin indices, of which one marks the hours, the other shows, by a complete revolution of the sphere, every hour and each single minute [of the 60]. The clocks being properly arranged to the true motion of the Sun at the meridian moment, I found the right ascension of this star to be $0^{\circ} 53'$. To this there corresponds, in the dodecatemorion of Aries, $0^{\circ} 50'$. These minutes of Aries have a northern declination from the equator of $20'$. The complement of these, to a quarter of a circle, is established as $89^{\circ} 40'$. The complement of the maximum declination of the Sun, moreover, amounts to $66^{\circ} 32'$. By means of these complements, the angle of coincidence of the zodiac and the meridian is gathered as $66^{\circ} 32'$. By this angle, and by the $61^{\circ} 32'$ of the star's declination — and 50' [marked with a $\underline{\vee}$ / "V" sign] — the true latitude from the ecliptic is elicited as $53^{\circ} 44'$. Then, by the arc of right ascensions from the beginning of Cancer in the preceding signs, up to $0^{\circ} 53'$ — that is, $89^{\circ} 7'$ of the principal of the equator, and through $28^{\circ} 8'$ — the complement of the star's declination is elicited as $28^{\circ} 7'$. By this arc, and the complement of the latitude, $36^{\circ} 16'$, the arc of the ecliptic from the beginning of Cancer toward the equinox

at the equinox, into the following signs, at $37^{\circ} 10'$. Therefore this new star is found at $7^{\circ} 10'$ [of Taurus], the dodecatemorion of Taurus, with a northern latitude of $53^{\circ} 44' 0''$.

A Critique of What Camerarius Has Put Forward

What this author says at the outset about the star's first appearance, its apparent magnitude, its shape, and its position, expressed in general terms, is quite acceptable. But when it comes to the observations—from which the very core of all our knowledge about this star must be drawn—then, even though he applied no small diligence in conducting them in the proper manner (for among the Germans there are many to be found who have handled this whole business far more carelessly and incompetently), nonetheless in the fine measurements themselves he by no means achieved the precision and exactness he claims. This may be because his instruments were not in every respect skillfully made, or because the sighting [collimatio] was set up with insufficient accuracy, or because of both factors together, or for some other cause whatever. The very inconsistency of his observations makes this plain, since they yield now one zenith-distance and now another, even though in reality these distances remained the same for as long as the star endured—as I shall now show in detail.

From the observation made on 23 November and the days following, the least distance from the zenith comes out as $9^{\circ} 30'$ and the greatest as $65^{\circ} 52'$. He says these were derived from the pole-altitude of $52^{\circ} 24'$ assigned to that place (about which, I admit, I myself doubt—and not without good reason, since by probable conjecture I judge it should be taken three or four minutes higher). I shall nevertheless retain the very value the author proposed. From these figures, following his own reasoning, the parallax is computed to be so great as to amount to a sixth part of a degree—if we assume it was put together correctly, since through some carelessness he may have committed an error, and we take it as he set it out. But if we have properly separated these two values from one another as we ought, the nearer parallax [parallaxis citima] will be about $8'$ and the upper one, near the zenith, $2'$. This same Aggregate of Parallaxes he gathers from the subtraction of the star's two declinations, those measured above and below the pole; yet to this he wrongly adds two minutes, with no cause requiring it. And so he still further inflates, quite incompetently, a parallax that was already excessive in itself—when in fact there was none at all.

But that even this much did not exist, the subsequent observations made with the same instrument sufficiently attest. For proceeding by the very same method of

reasoning, around the beginning of January he found a parallax more than half smaller than before, namely $4\frac{1}{2}'$.

Then, as summer advanced, from the observations made in April and August he found the greatest distance from the zenith to be $65^{\circ} 40'$ and the least $9^{\circ} 34'$. The Aggregate of Parallaxes comes out as no more than $2'$.

The author himself supposes that this diversity of parallaxes, by which they were successively altered, gave him grounds to think that the star gradually withdrew from a lower position into a loftier one, and rose higher (as he himself puts it)

into the firmament. But that this cannot be admitted I have already argued several times before: for such an ascent would have had to take place along a straight line, if the star were going to remain perpetually in the same place. And yet I have shown earlier that rectilinear ascents and descents of this kind in no way belong to the heavenly bodies. Even if such a thing could be granted in any way—which is in itself absurd—Camerarius's observations, gathered as they were with a single instrument and that one (as is more than likely) not free of every fault, in no way suffice to prove and establish so subtle and exact a determination with certainty. Indeed, that they are by no means to be trusted is shown clearly enough by their very mutual disagreement and ineptitude. For if the star had successively passed into the deeper recesses of the heavens, the distance from the zenith would have been increased by some minutes, not rather diminished—because the parallax itself would then gradually have become smaller. This is plain to anyone of understanding. Yet he makes the distance from the zenith around the end of November $9^{\circ} 30'$, whereas at the beginning of January it is $9^{\circ} 33'$ —greater by $3'$ on that account. And in August he extends it beyond the degrees mentioned to $34'$ —that is, he enlarges it by four minutes more than at the start; whereas it ought rather to have become smaller, if the star, with the parallax gradually diminishing, had lifted itself higher into the sky. And so, from this single absurdity it is beyond all doubt manifest that this author's observations are by no means to be trusted, nor carried to such precision that one may credit them with so subtle an investigation of the parallax.

As for the fact that in later times he detected a different and ever-smaller parallax, I do not think this happened because the parallax in truth diminished and the star ascended higher. Rather it was because, through longer practice and handling, he learned to apply his instrument more correctly and to set up the sighting more faithfully—or perhaps the aforesaid Camerarius even learned to correct certain things in these matters. For as the proverb has it: *We become craftsmen by practicing the craft* [Fabricando fabri fimus].

Therefore it will by no means be granted that these observations are reliable to the last degree, or that anything certain can be concluded from them about the star's ascent. Yet from them it has been possible to prove, beyond all controversy, that this adventitious star did not shine for us in the elemental world below the Moon, but far above it, out of the deepest aether. For if it had touched only the borders of the Moon, it would, on such reasoning, have implied a parallax of a whole degree.

What is more, I am astonished that he adds these very words: that the star produced no parallax at any time—which in itself was perfectly true. And if he had held firmly to this single judgment, and mixed in nothing discordant with it, he would have proclaimed the simple truth, and much more correctly, in determining the position of this star. But since in this respect he contradicts his own observations set out earlier, and undermines them, I really cannot see how the two can stand together at the same time and be reconciled. There is, however, no doubt

that this latter decision is the sounder one, and that in the preceding observations some fault lies hidden.

Afterwards he declares that he is at least asserting—following the received opinion of the natural philosophers—that comets are generated in the sublunar air, but that this is not demonstrated geometrically from sure observations (since not even Aristotle, the standard-bearer of those philosophers, accomplished this in the works he cites; whence, on this point, he deserves no more credence than his followers). This, I say, was put forward by this author very aptly and truly; and that this far-too-long-entrenched opinion of the natural philosophers is not merely doubtful but downright false, the following volumes, which deal at length with this cometary business (so to speak), will prove without any rightful hesitation.

What he afterwards adduces—that this star, by mere ocular inspection, through a comparison made with its neighbor in the asterism of Cassiopeia, the one that is eleventh in number, showed that it is in no way to be assigned to the sublunar world—is by itself sufficient, in establishing the truth by a rough sort of investigation, to earn it a place. For indeed it could be discerned, by the very eyes and without any instrument at all, that this star was not subject to any perceptible parallax. And since he reports that the interval of the New Star from the said star of Cassiopeia was the same both above the pole at its greatest altitude and below it near its declining position, he establishes—certainly, whether he knows it or not—that it is utterly free of any parallax. But in claiming

that the distance of the New Star from the eleventh star amounted at most to 50', he constricts it far too much. For without any doubt that distance was $1^{\circ} 1' 31''$, as we indicated in chapter 4. And so it makes this interval somewhat more than a full degree smaller than it ought to be—which is an indication that his instrument was not suited to measuring the distances of stars, nor properly equipped. And since in this close arrangement, with respect to a distance that could more correctly have been measured by the eyes alone, he went astray, it is not so very surprising that in those few minutes regarding the altitude—or the measurement of the distance from the zenith—he deviated from the true mark itself.

Furthermore, in setting out to investigate the longitude and latitude of the phenomenon, he rightly says that this cannot be found without error from the fixed stars, whose true positions have remained unknown until now. But while he busies himself with carrying out this investigation by means of one clock or another, however notable for its indication of the minutes, in sailing between Scylla and Charybdis—turning aside from the one whirlpool—he does not avoid the other. For from clocks, however subtle and carefully crafted they may at last be, those exact moments of time which are required here—or known in a few seconds—are not safely obtained, a matter whose occasions I set forth in chapter 1. I pass over for now the fact that the situation of the meridian needs first to be established here exactly, without any deviation. And what was most to be desired: the very position of the Sun is not yet so well known from any tables that one could build this practical procedure [Pragmatia] upon it without evident error—

with sound result. And if the author himself had noted the day on which he set up this observation for tracking down the right ascension of the New Star—and if it had been displayed from our tables or ephemerides, mentioned in chapter 1—it would have been plain by how enormous an amount, with respect to the Sun's place, the hitherto received canons he employed went astray, whatever they were, and how far on this single account they pushed the right ascension of the star off course. For while he makes it 53' beyond the vernal intersection, he increases it by 26' more than is just. The truest right ascension of the star was in fact $0^{\circ} 26\frac{2}{3}'$; so that in rendering it more than twice as great, he commits an error of nearly half a degree. Nor does that other claim of his hold good either—that the right ascension of 53' in the ecliptic corresponds to 50' of the first degree of Capricorn; for it is rightly established that 58' ought rather to be allotted to it, or nearly so. Hence the rest of what he superadds is of little force.

Nonetheless he finally gathers (proceeding by a certain method of his own, intricate as it is, though a much plainer one could be had) what he was aiming at—not so very far from the true track, as regards these given data of the right ascension and declination. Diverging from them, he renders the longitude of the star at $7^{\circ} 10'$ of Taurus, where in the fourth part of the degree he makes it greater than it should be—just as that place which we tested in many ways in chapter 5 (which requires six minutes to complete the sixth degree) testifies. In fixing the star's latitude he deviated imperceptibly, for in rendering it $53^{\circ} 44'$ he falls short by a single minute from what we demonstrated by our own method in the same place.

But that this very thing which we said—that this operation could have been carried through to its proposed goal by a plainer track, and that he (although by a perplexed method, and one not even sufficiently consistent with itself in arriving at the required result) did not nonetheless deviate too far from the ultimate determination of the star's longitude and latitude—may be seen, I should like here to repeat the same figuration which we used several times in chapter 5, and afterwards elsewhere, in investigating the star's longitude and latitude from its given right ascension and declination. Here the whole business is most conveniently resolved by means of a single triangle.

Diagram. A circle (the sphere shown in outline) within which arcs of great circles intersect to form a spherical triangle. The relevant points are lettered. Near the top of the figure, A and B mark two poles; C marks the intersection point a little below them where the arcs cross; the symbol for Cancer (♋) appears at the upper right on the rim, the symbol for Capricorn (♐) at the lower left, and the symbol for Aries (♈) at the bottom. The triangle of interest is B–A–C.

- A (upper center): pole of the equator
- B (upper left): pole of the ecliptic
- C (just below A–B, intersection): the star's position (the third vertex of the triangle)
- ♋ (upper right, on rim): Cancer
- ♐ (lower left, on rim): Capricorn
- ♈ (bottom, on rim): Aries

In the assigned figure, then, let BA be the difference between the poles of the ecliptic and the equator, which here, together with the author, we assume in its commonly received value of $23^{\circ} 28'$. CA is the complement of the declination established by him at $38^{\circ} 8'$. The angle BAC, counted from the Tropic of Capricorn

up to the given right ascension, is reckoned at $90^{\circ} 53'$. Therefore the third side, BC, will be made evident as $36^{\circ} 17\frac{1}{2}'$, the value assigned to the complement of the star's latitude. And from the three sides, now known, the angle

the angle ABC comes out alone as $52' / 48''$, which measures the difference in the star's longitude reckoned backward from the beginning of Cancer. From this it follows that its longitude falls at $7^{\circ} 12'$ of Taurus [P. 7. M. 12. 8]. As for the latitude, once the complement investigated earlier is taken into account, it presents itself at $53^{\circ} / 42\frac{1}{2}'$ [P. 53. M. $42\frac{1}{2}$]. These two results depart from Camerarius's own computation by only a few seconds one way or the other — a discrepancy that could well be excused, provided the data themselves were not too greatly in error, both as to the right ascension (as I have said) and somewhat also as to the declination he employed. But I will not heap up more about these matters: readers of intelligence, if they are with me, will easily judge for themselves the rest, which is otherwise of no great importance.

Let this much, then, suffice as the considerations I have noted and duly examined concerning Elias Camerarius [Elias Camerarius] in connection with this star. Now I would proceed straight on into Silesia and Bohemia, as though traveling a road leading there through the middle, if anyone besides the one man Dr. Thaddaeus Hagecius [Tadeáš Hájek] — whose conceptions I examined in the preceding chapter — were to be found who had published anything in print there about this star. But since (so far as I know) no one else has undertaken so lofty a task, and since among the rest my old friend Bartholomeus Schultetus [Bartholomäus Scultetus], an industrious cultivator of mathematics, is also silent on it — though he did treat the comet that followed very carefully and laboriously (and, I would hope, just as truly), as will become clear in the following book — I shall therefore step aside a little from this point toward the west, and we shall examine what the son of that elder Erasmus Reinhold of most praiseworthy memory, living at Erfurt or in its vicinity, has brought forward.

ERASMUS REINHOLD THE YOUNGER.

Concerning this star, certain things — written for the most part in the German tongue — were appended to a particular astrological prognostication for the year 1574, composed in the common manner [Margin: Reinhold's tract, 1574] by the son of that elder Reinhold [Erasmus Reinhold the Elder], the compiler of the Prutenic Tables [*Tabulae Prutenicae*] and otherwise well deserving in the science of astronomy: namely the most learned mathematician Erasmus Reinhold [Erasmus Reinhold the Younger], Doctor of Medicine. I recall once conversing with him, when I was passing through Saalfeld, about the surviving remains of

his distinguished father's work. There, among other things, he showed me the Prutenic Tables worked out to single tenths of a minute as regards the prosthaphaereses [prosthaphaereses] of the planets, and enriched in certain other respects. And it seemed to me — so far as I was able to judge from familiar conversation alone in so brief a time — that he was no unworthy follower of his father's learning in mathematical studies; except that, perhaps because his domestic circumstances so required, he cultivated these pursuits more sparingly than the medical profession, which is more profitable. We shall therefore set out briefly what he brought forward concerning this star, since the material itself is in any case not very extensive.

After he had first remarked a few things about the magnitude of this miracle — that it surpassed the grasp and judgment not

only of ignorant and unlearned men, but even of the most erudite of any sort, men who professed an outstanding knowledge of philosophy — he adduces a number of observations by which he confirms this and the rest of what he builds upon it. These I shall here append in his own words (those portions of this part that were in Latin), together with his notation of the numbers.

Item	Degrees	Minutes	Seconds
Apparent greatest altitude [Visa Altitudo summa]	79 Grad.	30 Minut.	0 Secund.
Its parallax [Huius Parallaxis]	0 G.	0 M.	34 S.
True greatest altitude [Vera Altitudo summa]	79 G.	30 M.	34 S.
Apparent least altitude [Visa Altitudo ima]	23 G.	2 M.	30 S.
Its parallax [Huius Parallaxis]	0 G.	2 M.	56 S.
True least altitude [Vera Altitudo ima]	23 G.	5 M.	26 S.
Altitude of the pole [Altitudo Poli]	51 G.	18 M.	0 S.
True declination [Declinatio vera]	61 G.	47 M.	26 S.
Apparent declination at	61 G.	48 M.	0 S.

Item	Degrees	Minutes	Seconds
greatest altitude [Declinatio visa in summa Altit.]			
Apparent declination at least altitude [Declinatio visa in ima Altit.]	61 G.	44 M.	30 S.
True latitude [Latitudo vera]	53 G.	35 M.	30 S.
Apparent at greatest altitude [Visa in summa Alt.]	53 G.	36 M.	0 S.
Apparent at least altitude [Visa in ima Altitud.]	53 G.	33 M.	14 S.
True place [Locus verus]	7 G.	12 M.	26 S. ✕ [always remaining the same to itself / semp sibi constans]
Apparent at greatest altitude [Visus in summa Altitud.]	7 G.	12 M.	45 S. ✕
Apparent at least altitude, by reason of parallax [Visus in ima Alt. ratione Parall.]	7 G.	10 M.	33 S.

- Distance from the center of the Earth: 1079 semidiameters of the Earth, and a little more [Distantia à Centro Terrae 1079 Semidiametrorum Terrae & paulò plùs].
- Its diameter on 25 December of the year '72 was 5385 German miles [Diameter eius 25 Decembris Anno 72 fuit 5385 miliarium Germanicorum].
- Its proportion to the Earth was then about 31 to 1 [Proportio eius ad Terram ut 31 ad 1 ferè tum temporis].
- Then through January and February, diameter 3243 miles [Inde per Ianuarium & Februarium Diameter 3243. miliar.].
- Proportion to the Earth about 13 to 2 [Proportio ad Terram ut 13 ad 2 ferè].
- From the end of February to the middle of May, diameter 2167 miles [A fine verò Februarij ad medium Maij, Diamet. 2167 miliar.].
- Proportion to the Earth 2 to 1 [Proportio ad Terram 2 ad 1].

- From the end of May to the end of August, when these things were written, diameter 1838 miles [A Maij fine ad Augusti finem, quo haec scripta sunt, Diameter 1838. Miliar.].
- And therefore throughout this whole quarter of the year the proportion never changed, but was as 67 to 50 [Atq; idcirco per totum hunc Anni Quadrantem, nunquam mutata proportio fuit, quae erat ueluti 67 ad 50].

These observations, on which he relies, are found to have been by no means gathered from the heavens by Reinhold himself, but rather by the most illustrious Prince Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel] — from wherever he eventually obtained them. I am astonished, moreover, that he dared to publish them as his own (without any mention of the Prince, who obtained them with his own instruments). That this is indeed the case is sufficiently clear from the observations of the said most illustrious Prince, communicated to me by His Highness himself, which I set out at the beginning of Chapter 8 [Cap. 8]. For there exactly the same greatest altitude of the star is recorded for 26 December as $79^{\circ} / 30'$ [P. 79. / 30]. And on 29 December the same least altitude likewise as $23^{\circ} / 2\frac{1}{2}'$ [P. 23. / $2\frac{1}{2}'$].

Moreover, he assumes here the very same altitude of the pole that the Prince at that time assigned to the city of Kassel from certain of his own observations, namely $51^{\circ} / 18'$ [P. 51. / 18]. But this surely fits neither Saalfeld, which lies much farther south, nor Erfurt, if he was living there at the time. For although Erfurt lies on the road from Leipzig toward Kassel — two places that are found from observations to have exactly the same latitude — nevertheless Erfurt declines somewhat southward off the direct line, and on that account yields a slightly smaller pole altitude. There can therefore be no doubt that these are entirely the Landgrave's determinations of the New Star that Reinhold sets forth.

In one respect, indeed, he seems to have proceeded a little more carefully in them: that he distinguished the parallax of the greatest altitude from the one that occurred at the least. Yet how truly he collected the true place of the star so precisely down to the very seconds, he does not show — granted that he does not even hold himself accurate to within minutes, let alone beyond a quarter of a degree. Nor could he have elicited it from the prescribed data, unless more had been at hand; nor does it agree with the Landgrave's own findings as set out in their proper place. But [Margin: true latitude] let the true latitude of the star, which he gives as $53^{\circ} / 35\frac{1}{2}'$ [P. 53. / $35\frac{1}{2}'$], stand as it may, since on that point it falls short of the star's exact quantity by a sixth part of a degree — to say nothing of the erroneous longitude.

But as for the fact that these parallaxes derived from the Landgrave's observations — however subtly, in the end, those observations were gathered (as I have just shown) — are too large, and do not square with the star's genuine position, which it actually held in the eighth sphere [eighth sphere / Octava Sphaera]: this is because, in examining the most illustrious Prince's own observations, I have shown sufficiently above, with the added reasons why that tiny deviation was probably committed, as I gathered. I therefore do not think it worth the trouble to repeat all this here tediously — especially since the Prince himself was unwilling to vouch for those three seconds, whether the star really had so great a parallax at all, inasmuch as such a thing is very easily missed in observing, unless the most exact instrument is employed. I am sufficiently aware of this. And since this star was beyond all controversy subject to no parallax whatever, or to the very least, Reinhold ascribed some such parallax to it in vain, and undertook in fruitless labor to distribute it in latitude and longitude, both about the vertex and about the horizon, and thereby to alter its declination — since the apparent place departed in no way at all from the true place throughout its whole daily revolution. And if the parallaxes had been such as Reinhold presupposes, then its distances from the Earth and the magnitudes he reports would have been in some way tolerable. Yet how he could have counted the star's true diameter in miles so precisely, when he draws no apparent diameter from the observations — which, compared with the distance from the Earth, would determine the true magnitude — that, I confess, I do not see. And to settle the matter in few words: since the parallaxes themselves which he

alleges as his foundation were by no means such as he claims, but in reality were utterly nonexistent, all the rest that he builds upon them — concerning the difference of the true and apparent place with respect to the equator and the ecliptic, the distance from the Earth, the true diameter of the star, its proportion to the Earth, and the change attending it — turn out to be superfluous and altogether foreign to the matter itself. As for what could be more correctly demonstrated about these points from observations that are not at all doubtful, those things have been set out by us without ambiguity in the Second Part of this Book. Whoever wishes may carry these matters across to that place and compare them. He will then readily discern how far the two diverge — by nearly the whole heaven.

From this slenderness of the parallax, which had not exceeded three seconds, he nonetheless gathered well enough that the star we are treating had far transcended the abode of the Moon.

And from this point, in setting out to inquire what this star may have been, he established without difficulty, by the arguments he adduces, that it deserved to be reckoned neither a planet nor even one of the fixed stars. Here, among other things, when (by way of Capella's star [Capella]) he reports that it kept the same declination of $45^{\circ} / 7'$ [P. 45. / 7] and the same longitude of $16^{\circ} / 10'$ of Gemini [P. 16. / 10. II] on both sides, above and below the pole alike — by way of proof — this is not founded on sure observations, but only on tabular calculation. For at that time, by our own verification gathered from the heavens, this star's declination was $45^{\circ} / 27\frac{1}{2}'$ [P. 45. / $27\frac{1}{2}$] and its longitude $15^{\circ} / 52'$ of Gemini [P. 15. / 52. II], with latitude $22^{\circ} / 51'$ North [P. 22. / 51. Bor.] — which differ greatly from his own annotations. Therefore, although in what he labors to introduce concerning this New Star his individual points may incur no contradiction, nevertheless the fact that he adduces an example drawn from some fixed star, not from the heavens but sought from paper records, and one not in agreement, makes him liable to censure. Indeed, that this star had not been illumined by the Sun or from any other source belonging to the ancient Cassiopeia [Cassiopeia], scarcely needed so great a refutation.

He furthermore produces reasons, by no means to be despised, why this star should not be assigned to the number or nature of comets: namely, that comets have never lasted so long, nor do they display such a form, and that on account of their vaporous matter — which would not suffice for this star (though here, in imitation of Aristotle [Aristotle], he vainly maintains that comets are generated from terrestrial vapors; just as it is also assumed by him in vain that comets have so great a parallax that they turn out to be sublunar) — and furthermore, from the change of color (whereby, since comets do not change theirs, he proves nothing, seeing that it has not yet been altogether established that comets perpetually retain the same color). But as for the star's having been immovable, this it scarcely had in common with comets.

Lastly, in the place of a final proof, he adduces an argument from the falling stars [falling stars / *Stellae cadentes*]: namely, that with the air exceedingly clear he observed three times that this New Star, like the fixed stars, drew them beneath itself as regards appearance, and that — just as happens with the fixed stars themselves — they ran toward the north, and, leaving it behind, made for them. But this reasoning,

by which it is generated, this in my own judgment proves not so much that it was a comet—indeed in no way that it was this Star—but rather that it ought to be

associated entirely with the fixed stars themselves, since it shared with them the very origin of these falling sparks [of light].

Therefore Reinhold [Erasmus Reinhold the Younger] rightly concludes that this Star was not a comet, and that nothing could be put forward on which grounds it should be reckoned among them—except this one point alone: that it altered its size successively, just as comets too are wont to do. But since one swallow does not make a summer, he rightly judges that this single indication is not sufficient to establish that conclusion—especially when so many other features argue against it. He also labors to make the solar eclipse that occurred at the Passion of Our Lord serve as a parallel case, though with what aptness I would not care to say.

But when, after adducing several such reasons, he had confirmed that this Star was neither one of the fixed stars, nor one of the planets, nor even one of the comets, he finally concludes that it was some miraculous and new work of God—since on earlier occasions too certain things in the order of nature, by His own special will, have presented themselves outside the order established from the beginning, and no limit can be set to His power and will. All of this I consider to have been put forward by him quite piously. Yet whether this Star foretokened the consummation of the universe—as he goes on to hint, though I would hardly subscribe to it, since this does not seem consistent with the Oracles of the Prophets, with Christ Himself, and with the prophecies of the Apostles and of the Apocalypse—I discuss more fully elsewhere. But since these matters lie beyond not only the grasp of human beings but of all created things, and are known only to the secret counsel of God, it is vain for us to presume to affirm anything certain on this point. And since Reinhold himself, as far as the [astrological] decrees concerning this Star are concerned, restrained himself—and not imprudently—from astrological predictions, I too will forbear to discuss them, whether here or wherever else they are brought forward by various authors; I deliberately set this aside. Here, then, I will make an end with Reinhold himself, and will not inquire further into what he has set out.

Having therefore reviewed in this manner the views of all those, as many as I could obtain, in which this Phenomenon we are treating was placed among the planetary regions—and having weighed each by a just balance and, where the matter required, rejected them—it now remains, finally, that we descend to examine and refute the opinions also of those (far humbler though they are) who put forward nothing solid or astronomically demonstrative about this Star, and

who tried by certain frivolous lines of reasoning to make it altogether sublunar, or else attached to it claims that were excessively absurd.

* * *

CAPVT DECIMVM.

On the opinions of those who put forward, concerning this Star, nothing solid or properly to the point; and who, partly contending that it was not new, and partly that it was some comet, in the manner of a sublunar meteor, accordingly fabricated it [as such].

Of those who attributed to this Star some degree of parallax—so much that it could not be associated with the seats of the fixed stars, yet not so great as would render it altogether sublunar—I treated in the preceding chapter, having sufficiently weighed what they had put forward and recalled it to the anvil of truth. Now I intend to bring forward into the open those who, with less regard for the magnitude of the undertaking, were not ashamed to advance things far more absurd and far more deviant from the truth; to subject them to a just examination; and to clear them away by sound reasoning. For although the views which I intend to examine in this chapter are of such a kind that—because they are less than mathematical, resting partly on defective and useless observations, partly on none at all—they might be judged unworthy of refutation, and rather to be passed over in silence than to be weighed out with laborious consideration: nevertheless, lest these very opinions, of whatever sort, impose upon the unskilled and the unwary, and lure them off the path of truth into byways and empty notions, I do not think it altogether beside my purpose if I expend some effort also in examining and clearing them away. For this Star, so marvelous beyond measure in our age, I undertake to vindicate from the great wrongs and fictions with which some have afflicted it, whether through ignorance, or through some carelessness and inept inattention.

In this last chapter I will follow this order of arrangement: first, those who did not decide, on the basis of their own observations and demonstrations, whether this Star was celestial or rather elementary, but who put forward other things about it in a general way—especially as regards prognostications and the conjectures of prediction—I will examine. Among their number are Cyprianus Leovitius [Cyprian Leovitius / Cyprián Lvovický], David Chytraeus [David Chytraeus], and Gulielmus Postellus [Guillaume Postel]. Next I will append three others who held that this Star was augmented and made conspicuous partly from an elementary cause and partly from a celestial one—namely Hannibal

Raimundus [Annibale Raimondo], Frangiapanus [Frangipani], and a certain Anonymous. Finally I will discuss those who supposed it to have been wholly elementary and a sublunar meteor—among whom are Andreas Nolthius [Andreas Nolthius], Georgius Buschius [Georg Busch], and Theodorus Graminaeus [Theodor Graminaeus]. To these I will afterwards add three compilers of the annual prognostications, who pronounced about this Star neither the one thing nor the other:

—they merely augmented their annual soothsayings (weaving in, on the occasion of this Star, certain prophecies, or rather certain idle talk). From among these I will not omit to bring under scrutiny especially the select ones who were thought to speak more to the point than the rest, however slight the labor may prove worth.

And so that the matter be not drawn out any longer, I will begin the proposed inquiry with the noble and learned Cyprian Leovitius [Cyprian Leovitius]—a man otherwise well enough deserving in astronomical matters, especially as regards his calculation, but who here, in this lofty business, handled the matter coldly and carelessly.

CYPRIVS LEOVITIVS A LEONICIA BOHEMVS.

[Cyprian Leovitius of Leonice, a Bohemian]

Cyprian Leovitius—a man noble and distinguished both by his learning and by his lineage, descended from the family of Leonice [Leonice / Lvovice] of the Bohemians—published a few small pages about this Star, which he filled, under the title and pretext of Astronomical Observations, with merely astrological conjectures. And since these are slight in themselves and take up little space, I will not be reluctant to set them down.

Astronomical Observations pertaining to the new Star, or comet, recently seen: to which is appended a brief astrological judgment concerning its significations.

A new Star lately shone forth, splendid and great, greater than any planet, whose position in the heavens I began to examine on the 25th of November and on several of the following days with instruments. It was of varying color: toward the end of November it appeared with a pale, whitish color; at the beginning of December it had a reddish color, and as it were blood-red. Afterward, around the middle of December, it took on a certain mixture, while it partook of the several

colors singly. From this it may be reasoned that this Star was kindled from the star of Jupiter and of Mars; of which two planets, Jupiter especially, since it is not far from the Dodecatemorion [Greek: δωδεκατημόριον (dōdekatēmōrion, "twelfth-part" — a zodiacal subdivision)] of Taurus, under which this Star shines, is distant [from it]. For the new Star occupied a place of the heavens which is referred to Gr. 8 of Taurus [Margin: ?], and obtains a northern latitude from the ecliptic of about Gr. 50. It falls, with its body, exactly into the seat of Cassiopeia, and touches that part of the seat against which the rump of Cassiopeia rests. And because the constellation of Cassiopeia is near the Pole of the World, and on that account is perpetually visible to us, and is never hidden by reason of the Primum Mobile, it comes about that this Star too has always stood above our horizon and has been carried around in the form of a gyre; and in the afternoon, when even the rays of the Sun were declining and growing duller, it could be seen seasonably—say, within the second and third hour after midday. Its magnitude, moreover, and brightness were remarkable; and finally, its distance from the Zodiac was so great that the solar rays could in no way altogether suppress it. As for any motion that the Star might have of its own nature, I could detect none. Accordingly it remained in one and the same place for nearly two whole months. But now, within a single month, this Star seems to me to have advanced somewhat, to three degrees toward the north, in the direction of the constellation of Cepheus; and it decreases day by day more and more in magnitude

and in its splendor, so that I think it will vanish within a short time. But in its decrease it is tinged all over with a red, blood-like color. The effects of this Star are without doubt great and conspicuous. Histories report that in the time of Otto the First, Emperor, a similar Star blazed up in almost the same place of the heavens, in the Year of the Lord 945. After this, very many great changes and a variety of evils ravaged the provinces of Europe—chiefly on account of foreign peoples poured into Germany. But there exists in the histories a much richer testimony concerning the Year of the Lord 1264, when a great and bright Star appeared in the northern part of the heavens near the constellation of Cassiopeia, likewise lacking a tail and destitute of any proper motion of its own: for a little afterward two of the most outstanding and flourishing families of Germany were cut off; and among the Electors and Princes of Germany the greatest dissensions arose, and there followed an interregnum and a great slaughter [Ianienam] over very many years. Doctor Achilles Gassarus [Achilles Pirmin Gasser], a distinguished physician and natural philosopher of Augsburg, prophesies through this Star—just as it has also been written to me by others—a severity of winter, and the death of certain magnates: a thing to which I readily assent. For the constellation of Cassiopeia consists of Saturnine stars, which incline toward

coldness; Cassiopeia likewise denotes one seated on a Royal Throne, persons illustrious and powerful, and the helm of the commonwealth: men in moderate station, since to the one ruin, to the other a more depressed condition, or destruction with shameful treachery or flight, is portended. And it is certain that the effects of this Star concern all Europe—but especially the Roman Empire and its members; and that to some they will not be without excessive calamities and ruinous things to come: that is, when they are compelled to throw off their former liberty and to take up an intolerable yoke. Nor, moreover, will men, regions, and cities lying beneath the sign of Taurus—which I have need to review here—be immune from various hardships and disasters; let them beware the danger.

An inquiry into the things that Leovitius here put forward.

That at the outset he calls it a New Star, he does rightly, and in saying so about its apparent magnitude he says nothing amiss. He says that he examined it with instruments on the 25th of December [Margin: ?]. But with what instruments, in what manner, and what things in particular were observed? Why does he pass these over in silence, and not adduce into the open the very thing that was fitting? The change of color, of which he soon speaks, could be discerned by the unaided sight alone, with cheap instruments. He did not, indeed, note even this accurately enough, as is plain from what we reported in Chap. 3 concerning the alteration of color. So too, when he reasons from its color that this Star was kindled from Jupiter and Mars, he is altogether without any just warrant. For stars do not kindle or beget stars: otherwise there would be a nearly infinite, indeed boundless, multiplication of this kind, nor could the heaven itself sustain so many newly sprouting broods of stars. And if he judged that this Star had been a comet—as he afterward improperly calls it—and that it had condensed from dry vapors in the sublunar air, as the followers of Aristotle [Aristotelici] dream, and that it had been drawn to and kindled by a certain position of the stars, as the astrologers vainly suppose: he entrusted this business rather to the frivolous authority of these men than to the investigation of truth, or to sure reason. For comets are in no way sublunar, nor compounded out of vapors, nor are they broods of the planets, set ablaze by the burning of the authors [of such notions]: as will be perceived more clearly than the noonday light from the books that follow.

escapes him here. Nor did it help his case at all that Jupiter was then moving through the Dodecatemorion [duodecimal subdivision] of Taurus, so that the star's position in longitude would coincide with that point. For Jupiter passes

through the sign of Taurus once every twelve years, yet no new star was ever created near Cassiopeia on that account—whereas this star was fixed. Jupiter is a moving body; this star is motionless. The one travels in the zodiac, far removed from this region and toward the north. It is true that from the outset it displayed a brightness and a color much like Jupiter's, enough that one might plausibly infer it shared in Jupiter's nature. But to claim that it was kindled by Jupiter, or by Mars, or by any other planet whatever, is an empty assertion, devoid of any foundation.

He puts its longitude at 8 degrees of Taurus—a full degree more than the truth. And in latitude he strays still further off, making it at least 50 parts [minutes], where it very nearly reaches 54. Is this the way to report such an unusual phenomenon by astronomical means, when one wanders away from the mark by a whole degree in longitude and by nearly four parts in latitude? O instruments! O observations!

The remaining points he adds about its location near the constellation of Cassiopeia—that it never sank below the horizon and was sometimes visible even by day, and that by its remarkable size and brightness it was not unsuited to being seen by anyone—are accurate enough, and could have been observed by anybody. Nor is he wrong to say that from the beginning it had no motion at all, but stayed in the same place over the course of two months. But when he goes on to say that afterward it advanced three degrees northward, toward Cepheus, this is utterly foreign to what actually appeared. He thus did the star a real injustice through his careless inattention: the star that, throughout its whole duration, never shifted its seat by so much as a single minute. For it was never observed by anyone to have altered its original position in any way—so much so that I cannot wonder enough what led Leovitius to assert this so confidently. But I see at last how he fell into so enormous an error. Lacking suitable instruments, he at first cramped its latitude too tightly, by nearly four degrees. Later, observing the star a little more carefully and comparing it with the neighboring stars of Cassiopeia, he noticed that latitude had grown by about three degrees, and concluded that the star had climbed northward by some motion of its own. But this divergence resulted rather from the errors of his own instruments (if he used any) and from a misjudgment in his sighting [collimatio] than from any such thing genuinely belonging to the star.

This author, Cyprian Leovitius [Cyprian Leovitius], was excessively devoted to astrological predictions, on which he spent almost his entire life. And although in this field he surpassed certain other astrologasters [petty astrologers] by his great

care and diligence, I would not say that he practiced this predictive part of astronomy in a sound and proper manner. From a few particular examples he seems, all too confidently, to have repeatedly drawn universal rules and conclusions. He certainly produced many canons, and ephemerides for a great many

years, fashioned with skillful dexterity, immense and tireless labor; and he enriched this branch of astronomy as much as anyone. Indeed, most of his manuscript works—chiefly those serving astronomical calculations, and meant to make the tables of the Primum Mobile [primum mobile] fuller and easier to use—are kept, not without harm to the advancement of these arts, in the Fugger Library at Augsburg. Among them are, in particular, certain very convenient tables of directions [Tabulae Directionum], which number the oblique ascensions for each eighth degree of latitude, and several other things prepared more readily for practical use than before. There are also ephemerides for many years, derived not only from the Alphonsine but also from the Copernican calculation (all of which Cyprian himself once showed me, when I was visiting him at Lauingen). These lie hidden far too long, robbed of the light of publication: with what right, with what fairness, let others judge.

But to say how the matter really stands: Leovitius of excellent memory wore himself out, for all that long time, almost in vain over directions and unremitting labors in compiling ephemerides and refining the doctrine of directions by the canons of the Primum Mobile. For the result is that planetary motions by no means present themselves in the heaven itself as the Alphonsine Tables—on which he relied too heavily—reckon them; nor do the Copernican tables, despite what they promise, fulfill their office here. As for the directions, examining them in finer detail: if at certain points the degrees, the planetary positions, are sometimes less well known—not to mention that even these computations are not arranged exactly enough—. But these things belong to another place. Therefore, since he busied himself solely with astrological predictions and the calculations that serve them, while treating astronomy sluggishly and as it were perfunctorily, devoting himself only to the computation of tables drawn up by others, he was thus very little practiced in celestial observations. So much so that—as I still recall I once did, when I was traveling from Switzerland to Augsburg and passing through Lauingen (where, as I said, he then lived), and conferred with him familiarly about astronomical matters—I asked him, among other things, whether he ever kept watch by observing the heavenly bodies, so as to learn whether his ephemerides, computed so laboriously from the Alphonsine numbers, agreed at all with the heaven itself. He replied that he was without

suitable instruments; yet that he had attended carefully to certain solar or lunar eclipses by means of well-made clocks, and that he had now and then watched a conjunction of the Moon and Venus as well. And he said that, especially by means of the Fuggers' clocks, he had found that solar eclipses agreed more correctly with the Copernican calculation, while lunar ones came nearer the Alphonsine. He added, moreover, that the motions of the three superior planets squared better with the Copernican numbers, those of the inferior with the Alphonsine. From all of which it is plainly clear how negligently and without exact determination he persuaded himself of things, and how sluggishly and rarely he carried out astronomical observations. For if the Sun's motion, in one or the other of these calculations, behaved correctly or incorrectly,

it would surely carry over to the Moon as well—since in any eclipse, whether of the Sun or the Moon, the motion of either luminary must hold good correctly, if nothing is to be subtracted from the appearances themselves. In the three superior planets, indeed, the Alphonsine Tables depart from the heaven far more, for the most part, than the Copernican—as Experience itself, for the most part, attests. But in the two they call inferior, what he reported holds true only in the case of Venus, and only now and then: for Mercury, the Copernican calculation generally has the advantage over the Alphonsine. Therefore, since the said Cyprian Leovitius was so little practiced in treating astronomy fundamentally and in exercising it upon the stars themselves and in pronouncing about the heavens from the heavens—and since he went so badly astray over the very stars that are coeval with the world—it should be the less surprising that he failed to attend to this New Star, with the care and certainty its case deserved, that he set down its position so erroneously, and that he touched but lightly on the matters bearing on its astronomical consideration—to say nothing of the astrological ones here.

But I bring all this up not because I wish to diminish the Reputation and Learning of a man otherwise most worthy of praise and remembrance, which fate has already long since granted him. For I have always thought highly of him, and judged his immense labors in astronomical computation commendable. Moreover—as I mentioned earlier—when he was alive I formed a not unwelcome friendship with him: when I was at Lauingen, invited to lodge at my inn, I spent time with him in friendly and cheerful company late into the night, and afterward kept up our mutual remembrance unbroken. But I judged it worthwhile to give this warning, lest, on account of his published astronomical works, less-informed readers, drawn by the authority of his name (which many

otherwise abuse, in theological matters as much as in philosophical), should form a darker opinion of this Star than is fitting.

The decline in the Star's apparent magnitude happened just as he reports. But as for his claim that it was meanwhile tinged with a red and bloody color, that was not at all the case. It did indeed appear, in the spring of the year 1573, to take on a Mars-like, reddish color, like the star the Romans called Palilicium [Aldebaran]; yet it never displayed a bloody redness. Indeed, a little later, around the end of spring and the beginning of summer, it was seen to pass into a kind of livid whiteness—just as we set these matters out more fully in chapter 3.

The rest that Cyprian adds about the Effects of this Star I prefer not to dwell on at length, since these things, taken on their own, are thin, and have been stated in too general and broad a manner: nor do they properly suit the qualities and circumstances of this Star. As for his claim that stars of this kind had twice before been observed—especially when such a star, without a tail, blazed forth beside this very constellation of Cassiopeia around the year 1264—that would indeed be worth considering, if only

it could be established as true in fact whether it actually happened so. From the historical records hitherto published, certainly reliable ones, nothing of the sort is proved. He notes that he had this from a certain old manuscript Codex, whose author, however, he does not name—and surely, had this Star been so dazzling, the historians of that age would not have failed to record it in their writings. What is more, there would have been astronomers who would not have left so unusual a Miracle unobserved, but would have handed down a description of it to Posterity. But let whoever wishes hold whatever he likes: even granting that some adventitious star did then appear without a tail, it has by no means been sufficiently demonstrated that it was in all respects like this one, the one in question, or to be compared with it—and much less that the worldly events which (in Leovitius's opinion) accompanied that star were portended by this one, on the grounds that some similar things must be applied to it. Indeed, even granting that from that star (if there was one) of that time, by its foretelling, the portents he reports proceeded, and that this had an Astrological cause—that has not yet been adequately proved. In my own opinion he has pronounced too freely on such matters, as his little book *On Great Conjunctions and Eclipses* also makes plain. In it, whatever he finds to have occurred in this lower World a little after the time of such configurations, he ascribes all of it to those configurations, as if it took its occasion entirely and solely from them and from nowhere else. And so he attributes the most diverse effects, over and over again, to one and the same

closely similar Conjunction. Nor yet does he reason competently from past events to the foretelling of future ones—as those Prophecies he appended there, of which scarcely any has ever come to pass, abundantly testify. An Astrologer surely ought (so far as can be done), if he wishes to be truthful, not to draw a general conclusion from one or another single Individual, but to be himself more sharp-sighted than Argus, and prudent in pruning away and discerning all circumstances—so that the failures of one who professes this Art (which is perhaps not everywhere so empty as it is reckoned) are not undeservedly imputed to the Art itself, as usually happens. But what is the use of refuting these Astrological Predictions of Leovitius's at greater length, when Experience itself has taught—now that nearly 20 years have elapsed since the Appearance of this new Star—that none of what he prophesied from it has come to pass: or that, if anything could be brought forward under this pretext, it could have happened from some other cause rather than this one? Just as a great many things in human affairs occur every year throughout the whole Globe of the Earth, beyond and even worthy of everyone's notice and memory, even when no new Stars or Comets have preceded them. But to treat of these matters at greater length, since they also lie outside my own undertaking, I forbear: nor do I wish anything to be detracted, by this free and Philosophical admonition, from the fame of so great a man, deserving to be cherished with a grateful spirit. If only he had practiced the Astronomical Computation, in which he was thoroughly skilled and at ease, and either left Astrological judgments untouched, or at least handled them more moderately and circumspectly,

it would have been more honorable, perhaps not just for himself but for the whole discipline, and it would have been less exposed to slanders on every side. On these grounds Sixtus ab Hemminga [Sixtus ab Hemminga], who recently wrote against astrology — undermining it not so much with sound arguments as with plausible ones, easily refuted by reasonings and by experiments — could not restrain himself. Indeed, Johannes Bodin [Jean Bodin], too, writing copiously *On the Administration of the Commonwealth* [*De Republica*], does not refrain from attacking Leovitius [Cyprian Leovitius] for the errors he committed in his astrological predictions. He does not even spare that great Copernicus [Copernicus] over the threefold motion of the Earth and the variation of its eccentricity — though Bodin himself did not soundly understand any of these particulars — leaving out no biting reproach. Yet this rashness of judgment in a writer of history and politics could in some way be excused, since such matters lie outside his own profession. But where, in that very historical undertaking, he sometimes blunders so grossly and reports things so far from the truth, no excuse is warranted.

A witness to this — to pass over all the rest — can be this very homeland of ours, Denmark, whose administration and government (granting that it is at least called a principality) and whose inhabitants and their condition he describes as utterly trivial and entirely foreign to the truth. And all this he claims to have received from a man of the finest memory, Charles de Dançay [Charles de Dançay], for many years the ambassador of the kings of France to our own kings. Yet Danzaeus himself, while still alive, used to deny this in all earnestness. For I myself remember — and I heard it not once but often from him — that Bodin had in this matter wronged him gravely and undeservedly; he attested this also in letters written to one of our historians for the same reason, a little before his death: letters that will perhaps come to light in due time. But where is my just indignation, and my ardor to defend my homeland from such slanders, carrying me off? These matters should rather be left to those who write our history, lest I bring my sickle into another man's harvest — those who in their own time will set out these particular notes more fully and turn them back upon the author himself.

So now, returning to the matter I proposed: about Cyprian [Cyprian Leovitius] and his views I shall say nothing further here. But since, when he was writing about this new star, that most renowned and learned man Dr. David Chytraeus [David Chytraeus] was staying at Lauingen on the borders of Swabia — near which stretch of the German coast he was born, I believe — and since he too set down some things about this star in writing, we shall turn to examine his pronouncements. This is all the more fitting since he now lives on the nearby coast of Germany. From there, on account of the easy and almost daily crossing, we shall afterward make our way from Germany to the Danish Hellespont [the Sound], and from there presently set sail into the Western Ocean; and then, sailing on to France, we shall next (as we have determined) look into what Guillaume Postel [Guillaume Postel] observed there concerning this star, and submit it to its due assessment.

D. DAVID CHYTRAEVS.

Although that most celebrated professor of the University of Rostock, Dr. David Chytraeus [David Chytraeus], does not treat mathematical studies as his declared profession — for he expounds theology and history instead — he nonetheless never ceases, as far as in him lies, to do whatever serves to advance these disciplines whenever the occasion arises; and he is constantly urging eager young men to take up the knowledge of the science of the stars. In this he follows the footsteps and example of his teacher, that incomparable man of most

praiseworthy memory, Philipp Melanchthon [Philipp Melanchthon], who always commended the mathematical arts — and among them astronomy above all — with great earnestness to the students of the liberal disciplines, and drew many into this arena by his authority and encouragement. In this aim (as I have said) Chytraeus imitated him commendably; for it is the way of most of those who peddle theology to drive young men away from these loftier sciences and to deter rather than invite the most worthy and freely gifted minds from pursuing them — perhaps because they themselves are wholly ignorant of these subjects, or have scarcely glanced at them through a lattice, and do not wish their own pupils to turn out more learned and more clear-sighted than themselves. As the saying goes, *the heron befouls the water because it does not know how to swim through it*.

Now, concerning this star, the said Chytraeus published no separate writing of proper scope; but he first proposed some pages about it, by way of an admonition, in the school at Rostock, and afterward inserted them — not much altered or enlarged — into his commentaries on Deuteronomy.

But the things he committed to paper about this star from the outset — so far as concern its astronomical consideration and accurate determination — were set out in too loose a manner. He is right, indeed, in the very title page, to call the star unusual and new. But where he straightaway likens it to the comet that was seen toward the north near Cassiopeia under the reign of Nero, he is wide of the mark. For it has already been shown by us several times that it had nothing, or next to nothing, in common with comets. Nor again did it have anything to do with the conjunction of Saturn and the Sun in Scorpio, which occurred on the last day of October, and which preceded the first appearance of this star by at least (as I judge) five days. That it stood unmoved near Cassiopeia, and formed a rhomboidal figure with three of that constellation's brighter stars, was plain to all. But whether such a thing threatens — as the ancients, and especially Pliny [Pliny], who put this forward, suppose — wits, religion, and letters, I think is not sufficiently probable. For this arrangement of figures exerts no influence of itself, nor carries any portent, since it comes about rather by accident. And scarcely any place in the heavens can be found where a new phenomenon would not, amid so great a multitude of stars and such varied disposition, form some triangular or square configuration with certain fixed stars near it...

to a degree. Nor here, moreover, did all things correspond exactly. And although such a thing might be granted as conceded by some hidden cause, and although it is plausible — which he infers from the fact that, from its outset, Jupiter's radiance shone forth, and that it is therefore reckoned by astrologers to have

signified the state of the Church and of religion — yet it is certain that the decrees of the stars have no rightful authority over true religion and piety, since these proceed not from any astral influence or natural light, but from the Spirit of God alone and from his ordering. That the stars exercise their own powers upon feigned and counterfeit religions — and upon those accepted throughout the world — I would not deny, since even those who promulgate such religions are themselves too much governed by astral dispositions and influences. For (to set this out briefly): from Saturn comes avarice, tenacity, and crafty cunning; from Jupiter, ambition and an affectation of ceremony and statecraft; from Mars, wrath, quarreling, and a lust for vengeance; from the Sun, preeminence, titles, and the arrogance of dominion; from Venus, the pleasures of the table, enticements, and the bodily delights; from Mercury, ostentation of wit and learning, quibbling, and a knack for eloquence that catches the unwary off guard and draws them to one's side, cunning together with inconstancy; and from the Moon, variety of opinions, confusion, and a frivolous courting of popular favor. All these are obtained too presumptuously and too rashly. All of these draw their origin not from the divine light and the truly Christian and supra-Olympian doctrine, but from a terrestrial and academic — or rather (as I meant to say) "Adamic" — nature, which is microcosmic and subject to the impressions of the stars. But it is not the place here to treat these matters at greater length, since they are subject not to human but to divine correction alone. The thing is in itself all too plain, though no one may recognize *that he too has been mingled with the leaders, Achivus*.

But lest I seem to bring this charge undeservedly, and to take in too strict a sense — at Chytraeus's mention of religion, which could be understood in some broad way — a statement that is too narrowly framed, I will add some of his own words, which at last he appends in the latter part of this section, which he calls "the Admonition" [*Commonefactio*], and which run thus: *Although this star reflects the pure, bright, and clear light of Jupiter's nature, not that of the Martian and Saturnine stars, or of things born from the earth — by which a middling fertility seems to be signified — it announces, by religion and by a singular and notable change of doctrine, the death of the pious learned and of wise governors, in those regions especially which astrologers assign to Taurus, Aries, and Libra*. From this, therefore, where he names pious teachers and wise governors, and asserts that they are announced by a certain Jovial influence and nature, he attributes too little fittingly to the stars that piety and wisdom which God alone imparts to men; or, if he did not mean that, he subjects to the certain influences of the stars the special gifts of God — to no purpose. He is unmindful of that saying of Jeremiah

[Jeremiah]: *Be not dismayed at the signs of heaven.* And this surely pertains only to the truly pious and the divinely learned.

Since, therefore, beyond his own profession, he sets himself to play the astrologer and to fit the natural influence of the planets and the analogy of the signs to true piety and wisdom...

and so far as to attribute to these the change and ruin of those who administer them, he seems to play the theologian less within his profession, according to the truer and supernatural science, and the sound doctrine which those who are "of this world" do not grasp.

But to prove that this star differs from the other heavenly bodies, both fixed and wandering — although the common crowd has not noticed this distinction — he says that it stood about 50 degrees away from the zodiac toward the north, and that for this reason it ought not to be counted among the number of the planets. This is indeed true in itself; and he would have had to be exceedingly ignorant of celestial matters to have taken this star for one of the planets. But when he makes its latitude from the ecliptic at least 50 degrees, he commits an error of nearly four degrees.

That this star was not coeval with the world admitted of no doubt either: for it had begun newly, and gradually, once consumed, ceased to be. But it by no means follows on that account that it did not stand within the sphere of the fixed stars. For although both this star and comets are not perpetual and lasting bodies, and are not seen for very long, they are not for that reason banished from the heavens. Nor in fact do they exist as something fiery, of a globular mass burning in the highest region of the air out of the matter of terrestrial exhalations — as Chytraeus, following the opinion received and proclaimed in the schools, wrongly supposes. For how feeble and utterly groundless these notions are has been most clearly demonstrated, by indubitable astronomical and geometrical observations, in this book on the new star and in the following two on comets, which we have left to others.

Aristotle [Aristotle], indeed, distinguished two kinds of comets: one of which, having a globular mass of exhalations that is denser in the middle and rarer toward the edges, scatters a flame uniformly, like hair, around its body, and very often stands unmoved — and it is to this kind that Chytraeus likens our star. But this is without proper grounds. For this star deserved in no way to be compared to any kind of comet: it sent out no hair-like rays around itself, but vibrated its rays with a brilliant and clear light, like the rest of the fixed stars. And although

even this is not rightly stated — that the tails or hair of comets, of whatever sort they finally were, consist of a flaming nature — for they arise from the projection of the Sun's rays; and if the body of the comet is positioned opposite the Sun, or has become too far removed from the Earth, they are scarcely seen. And so the comets are then thought to be round and devoid of a tail, except that round about they appear thinner and not so compact and dense in the very middle. And this, for the aforesaid reason — as we shall explain more fully elsewhere — when we present the description of the comet that was seen in the year 1585 and was likewise without a tail.

He afterward appends a mention of the comet of the year 1556, and of certain others, and ascribes to these the things that were afterward enacted on the stage of the world. Just as...

even granting it remains uncertain whether those events were foretold by it [the comet]. For many other things, far greater and more conspicuous than these, also issue from the earthly stage with no comets heralding them. But since these claims and others like them — which he attached afterward — concern the prediction of effects (a subject it is least of all my purpose to treat), I will not unravel that material at any greater length.

In another work, which he appended here on the Comet of 1577, Chytraeus [David Chytraeus] put forward a far sounder and more considered view about this Star, holding that it stood in the aethereal region rather than the elemental one, on the ground that — by the assertion of certain practitioners — no parallax of it could be observed. If, therefore, he had grasped this from the outset, perhaps he would by no means have ranked it with ordinary comets. And yet, though these too are generated in the aether and not in the elemental world, he would not have believed it when he wrote of the said comet; he listened far too much to an inveterate opinion drawn from Aristotelian [Aristotle] authority.

As for the view of Seneca that he reports there — who rightly, on the basis of the opinions and doctrines of certain ancients before Aristotle, assigned comets to the aethereal world — Chytraeus thinks this Star could have had its place there. That much, as regards its position above all the gyrations of the planets, is not unsuitable. But as for Seneca's supposition that comets are stars in their own right, to be counted among the perpetual stars, which cut through the higher reaches of the world and only then appear, when they come to the lowest point of their course and are therefore nearer to us — this view earns no endorsement either in the case of this New Star or of any comets. I will make this plain in its

proper place, when I examine, along with Seneca, both these and the other opinions that have been brought forward.

But since Chytraeus published his *Expositions on Deuteronomy* a long time afterward, and inserted into them this very notice about the New Star word for word without any change, I am astonished that he altered nothing in them. This is especially so because, from the careful observations and geometrical demonstrations of so many distinguished astronomers in the meantime, he could have been advised and instructed more correctly and fully about this Star — namely, that what was displayed in this miracle was something greater, and rarer and more unusual, than that it should be put on a par with ordinary and familiar comets (even though this too is more than people could have imagined, since comets share in a more sublime nature). But I see that most of those who teach doctrines in the Academies cling too rigidly to that Socratic rule — or at least do not observe it aptly enough — namely, that one should always say the same things about the same matters. If those things are truly said, and no better can be substituted, this rule holds good. But if not, it is wrong to take up again, once they have been incompetently put forward, things that have been put forward, and to recook with distaste cabbage twice boiled.

Praiseworthy nonetheless is the zeal of that most learned man Chytraeus in proclaiming astronomical matters and commending them to studious youth, and his ready goodwill — just as I have extolled it from the start. He makes this sufficiently plain too in the conclusion of this little work, when he urges students, by the example of Hipparchus [Hipparchus] (on the report

of Pliny [Pliny]), to come to know and contemplate this new and unwonted Star, as they do the rest that are coeval with the world.

And at the end of his short account of the Comet of 1577 he adds, in the place of a conclusion, a certain striking pronouncement of Seneca, which runs thus: *Nothing has been sought to greater advantage, or learned more usefully, than the nature of the stars and heavenly bodies.* To this he aptly adds on his own account: *That the knowledge of such great things, of whatever kind, since it is most worthy of liberal minds, should be eagerly sought after and drunk in.* And — to say nothing of the fact that in a certain little book of his on the method of learning he does not hesitate to affirm that in the *Almagest* of Ptolemy [Ptolemy] (which professedly transmits the science of the stars) the very summit of all philosophy and human wisdom is contained — for this reason I would have students acknowledge and imitate, with grateful minds, the benevolent inclination and sincere devotion of

this Chytraeus toward these astronomical studies, which deserve to be promoted, and toward the cultivators of these studies.

Further matters concerning this most erudite man's writing about this Star — which in itself was not lengthy — I will not add here, but, leaving the city of Rostock, in whose Academy he has now for many years held the chief professorship, we shall sail back to our Uraniborg Muses, and, resting here a little, presently set sail through this Danish Hellespont and (as we have determined) make for Gaul. There we shall examine the publicly issued imaginings of Guillaume Postel [Guillaume Postel] concerning this Phenomenon, held forth there.

GVLIELMVS POSTELLVS GALLVS [Guillaume Postel the Frenchman]

What Postel [Guillaume Postel] published about this Star in a few small pages, and what he appended from the writing of Cornelius Gemma [Cornelius Gemma] on the same — insofar as it contains anything bearing on the matter itself — is at least comprised in brief in his very title-page. When he says there that it was without parallax, and remained in the same place with the magnitude it had assumed, and that among the stars of Cassiopeia it formed a quadrilateral or rhombus figure (which he called the figure of a cross, rather from a certain superstition than because anything of the kind was properly represented here), he produced nothing absurd. But almost everything else that he superimposes and applies to it is partly irrelevant, and partly contrived too harshly and forced as the whim took him.

For what he brings forward about the African origin, the customs and institutions, and also the occasion and significations of the asterism of Cassiopeia — even if some of it is drawn from older histories and seems plausible — yet for the greater part it reeks of poets' fictions. And some of it seems to have been devised by Postel himself at his own pleasure, especially as far as concerns the ritual books of Adam's Magic, which he says Cham [Ham], having stolen them from the Ark, gave to Cush his firstborn (from whom the Cushites or Aethiopians are descended), and that hence it came about that the Aethiopians excelled the other nations in Magic and Astronomy. Whether they had this

Science from books of that kind handed down by hand all the way from Adam, I judge to be utterly uncertain, since no mention of these things is made either in the sacred Scriptures or in Josephus [Josephus] or Philo [Philo of Alexandria]. Josephus indeed relates that the sons of Adam erected two pillars, on which they

recorded their astronomical discoveries, so that they might be openly displayed to posterity and not given over to oblivion. But of Adam himself and his ritual books of Magic he makes no mention. Nor is it credible that Adam practiced Magic, which consists of rites or superstitious ceremonies, much less that he transmitted such things to Posterity in books (of which there was certainly no use even then), with the vain intention of conveying them.

Yet it does not seem unsuitable, what Postel [Guillaume Postel] adduces about the cause of the great blackness of the Africans, especially of those dwelling in Aethiopia — namely, that it is not from the Sky at least, but also from the Sun, by a peculiar force, that this is proper to the inhabitants — on the ground that they are the posterity of Cham [Ham], who, because he had mocked his Father when uncovered, was, together with his whole offspring, stained by this mark of blackness both more inwardly and more outwardly. For there are, as he rightly says, other nations who likewise have the Sun standing over their own crests, and so directly beneath the very Equator, yet are not darkened over their whole body by such an obscure blackness.

Furthermore, as to the fact that the most ancient contemplators of heavenly things — whether in Aethiopia or elsewhere — gave the name Cassiopeia to the stars beside which this New Star appeared, and (as they report) called it after a certain Queen of the Aethiopians: this, in my judgment, contributes little toward ferreting out the Significations of this portentous Star. For those constellations, which we still mark by the same names according to the anciently received nomenclature, were for the most part devised and contrived by Gentile and pagan men, who were ignorant of the genuine names of the stars — names known to God alone, as the Psalm has it, or perhaps also to the Angels, with His allowing. What, then, will it supply us here — that Cassiopeia, Queen of the Aethiopians, with these stars beside which the New one stood, was admitted by the ancients (whether Magi or Astronomers), apart from the open declaration of God, after the manner of some Gentile? Is the work of the most wise God, and He Himself, in this way to be made subject to the vanities and arbitrary fancies of men, and to the Sky and the Stars? The rest that he mixes in here I do not care to discuss point by point, since they are sufficiently known of themselves and of no great moment.

As for the fact that he superimposes the idea that the New Star born to Cassiopeia announces a notable change, and the downfall of the Old Kingdom and the restoration of a New one — where too, from a likeness to the malice and cunning of the Aethiopians, and of the preceding Monarchies turned away from God, and

fornicating with this World, he conjectures, by the example of their abolition, that some other State of affairs and a new administration of Polity is foretold — that indeed is not without verisimilitude, nor lacking a portent. Yet it seems alien to the unwonted decrees of this miracle; and not so much on account of the Cassiopeia constellation itself, with which this Star was associated, as because the Colure

of the Equinoxes — and indeed its Vernal Semicircle — was occupied so high up [by it]. From this, changes of Commonwealths and laws are portended, as Ptolemy [Ptolemy] and other most ancient Astrologers attest.

Now the Roman Empire, which Nebuchadnezzar [Nebuchadnezzar] dreamed (with Daniel [Daniel] as expounder) to be represented by the iron and clay feet of the statue — and which others before Postel [Guillaume Postel] judged would, and reckoned would, last all the way to the consummation of the World: for by the stone cut without hands from the mountain, which will crush these feet, they wished to be prefigured and signified the final coming of the Son of God to the universal Judgment, and to the end of temporal life, and to the eternal restoration. But Postel — in which view several others too are found — seems to hint at yet another coming of Christ before the final Judgment: namely, that in His spirit He will come, within those members which He has chosen, and will scatter and root out blasphemies, heresies, idolatrous worship, and the World's vanities, impostures, and perversities, for the greater part, and for as long and as much as He shall will. So that, according to this view, the Coming of Christ ought to be threefold: one in the Flesh, a second in the Spirit, a third in Glory.

If these things are to be believed and approved (since perhaps the view does not seem at odds with the truth), some very great Catastrophe of worldly affairs will surely be imminent, together with another administration of Politics and of Religion (without doubt) will stand restored. On this matter, by my own censure, I wish nothing to be expressly stated. What will come about at all in these things, I judge to be known to God alone, and to exceed all human grasp and foreknowledge by many parasangs.

Besides this, it seems worth noting that by us too — before this little book of Postel's was published — in our Contemplation written about the first beginnings of the Star, and afterward published, according to that part which embraced the Astrological judgment (which above, among the matters to be repeated, we deliberately passed over) — it was brought forward: namely, that this Star fell in the seventh period of the Greatest Conjunctions celebrated from the world's beginning; and, what is more, that it indicated by its place the Colure of the

Vernal Equinox, near which those Greatest Conjunctions occur, and that on this account it foretells some great renewal of worldly affairs. Nor indeed are the things that Postel attributes to any given Conjunction, with respect to the events that followed, so very far from the truth — although some other things too could be joined to these. But truly, in this one point alone here lies the knot of doubt, which whoever has loosed will the more readily settle these matters: namely, whether the Years that we number from the world's first beginnings stand correct, or not. For I see that the ancient (as they call them) Fathers, in their own age, reckoned more than six thousand years; and the Orientals and Asiatics even now fix the time at more than seven thousand from the founding of things. Moreover, Josephus [Josephus] too — no contemptible Writer of Jewish affairs — says in the Books of the Old Testament that a History of five thousand years is comprised, before the

the Jewish commonwealth was crushed when Jerusalem was laid waste. And since from that time, beyond doubt, more than 1,500 years have passed, it follows that we are now more than 6,000 years from the Creation of the world, and well into the seventh millennium. There are besides many other opinions about the age of the world, gathered together by Gauricus [Luca Gaurico] and certain others, which I do not wish to review one by one. All of these — concerning the seven Great Conjunctions that have already elapsed since the beginning of the world, at least according to what is said — and the doctrine of the House of Elias, which is alleged by very many others, make Postel's claim to approval doubtful and tangled. I leave the sifting, the deciding, and the settling of these matters to chronographers and to any others who are thoroughly versed in such things. Meanwhile, the views here advanced in a manner that is in some degree plausible and pious in intent — put forward in this place by Postel and by very many other recent European writers, and above all by that most distinguished man Joseph Scaliger [Joseph Justus Scaliger], the corrector of chronology and an Aristarchus excelling all the chronologers of our age — these I judge are not to be dismissed.

Postel further calls upon, as evidence pointing to great impending changes, the fact that the constellations of the Zodiac have already migrated into another sign [Dodecatemorion], with the new sign taking the place of the one preceding; and from this he draws his foreboding. Now there is no doubt that the constellation Aries now occupies the sign of Taurus as nearly as possible, and the stars of Taurus the Dodecatemorion of Gemini (and so on for the rest): this comes about through the motion of the fixed stars [progressio Affixarum Stellarum], slow as it is, yet over many ages perceptible enough. But whether the upheavals of earthly

kingdoms are foretold by this, I do not think one may readily agree. For some 2,000 years before Christ was revealed in the flesh, the star-pictures of the Zodiac took over other signs from the original twelve, and 2,000 years before that, still others — the proper motion [motus proprius] common to all the fixed stars necessarily bringing this about. So it is that the constellations of the asterisms are not strictly bound to the signs [Dodecatemoria] named after them. But perhaps, at the time when these star-figures were first arranged, they happened in some way to coincide with the signs; and if so, then all things were established by the mere choice of men, though not without some reasons. Whether, then, these matters carry of themselves any great weight, I leave in doubt. And even if it were to be laid down as a rule, surely the first star of Aries, which furnishes the others their starting point, will not pass into the Dodecatemorion of Taurus within 150 years. And in all this another evident anomaly would suggest itself, arising from the inequality of the asterisms — something those well versed in these matters would readily perceive.

In the same way I judge the exposition of the words of the twelfth chapter [12. Cap.] of the Apocalypse — *a time, and times, and the dividing of time* [*Tempus tempora et dimidium temporis*], which Postel has brought forward — to be far too forced, and not the genuine sense; to discuss this more fully here would be unduly long-winded and would overrun the bounds of our purpose.

And since Postel has heaped up many other things elsewhere, presenting a certain appearance partly Theological,

partly Cabalistic, and partly even Astrological in their speculations — speculations that seem to rest on no everywhere sufficiently sound foundation, and that are all directed above all toward this one end, that he may from this build up, on the occasion of this Star, a kind of prophecy — I have, by dwelling too long on these matters, perhaps mingled in more of my own criticism than there was need of. Hence, whatever things concern the significations of this Star — provided we set ourselves either to leave them untouched, or to handle them more sparingly — let us not be very anxious about matters that cannot be demonstrated geometrically [Geometrice], or by other infallible proofs [infallibus tecmiriis].

Therefore, leaving aside Postel's speculations — partly empty, partly carrying some appearance of likelihood — let us turn to certain others who in Italy have likewise committed their imaginings about this Star to paper. For the passage from France will not be very difficult, even though the Helvetian Alps themselves [Alpibus Helueticis] offer some obstacle. Nor is there any reason for us to linger

longer over France in this matter, since no one there, so far as I know, has written anything about this New Star except this same Postel. We shall therefore now undertake to examine the writings of the Italians, who are neighbours to the French.

ANNIBAL RAIMVNDVS VERONENSIS [Annibale Raimondo of Verona]

So great is the variety and fluctuation of opinions among men in this fleeting and turbulent life, that there is hardly anything so absurd, and so at odds with all truth, that it does not find some publisher and some thoroughly shameless champion. For what indeed could be devised more incompetent, more insipid, and more remote from truth concerning this most wonderful sign of God, displayed to the heavens in our age — a sign such as has scarcely been seen for thousands of years, and was never seen before — than the things which Annibale Raimondo of Verona, with a certain presumptuous and arrogant boldness, has not blushed to put before the public? For that this Star — which all the inhabitants of the earthly globe who had any knowledge whatever of the heavenly bodies, and indeed even some untrained persons, in short very many among the common people, beheld newly arisen in the heavens, never before existing in that place, without any illusion of the eyes or the senses, and declared to be in no way new, but one of the old stars of the asterism of Cassiopeia, namely the eleventh in number — to affirm this, and publicly to testify to it, he did not hesitate in the least. Indeed, straying beyond the path of all certainty and without any modesty, he dared with a most brazen face to dedicate this writing of his to the Most Serene Prince and to the Illustrious, most excellent Greater Council of Venice [Maiori Consilio Venetiarum], and under their patronage to make it public — heedless that in a city and commonwealth so splendid and great, and in a trading-centre of all Europe most renowned for the vast concourse of men, there are very many, even in that most illustrious Senate itself, and among the rest

of the nobility, and among the citizens, who excel all others in keenness of intellect and dexterity of judgment. For I learned this — not without pleasure — about sixteen years ago, when I myself heard there very many men, distinguished by especial nobility too, disputing and conferring with great skill and acute penetration of mind about both other matters and philosophical ones. Moreover, the writings published by certain of them bear ample witness that learning, and the liberal arts, are diligently cultivated in that City and held in high esteem. So I cannot sufficiently wonder that this Raimondo was not ashamed to submit his absurdities to the censure of such excellent intellects and

judgments, and to offer them up for adjudication — and to do so with such insolent arrogance and obstinacy that he did not think it unseemly to despise those who held the contrary, to prefer his own notions haughtily and disdainfully, and to defend them tooth and nail [mordicus] without any hesitation.

He begins this writing of his with a foolish and empty protestation (I will say no more than that): that in his whole life he has never wronged the stars that are in the asterism of Cassiopeia, so that for their sake he should be forced to commit his own honour and reputation to the judgment of others. Surely, if the Stars could be insulted and wronged by men (as he superstitiously puts it), this Raimondo would have fixed no small mark of dishonour upon the Stars of Cassiopeia, since he does not recognize the eleventh of them as distinct from the New Star, but, removing it from its true and proper place, makes it one and the same with the New, increased besides, and augmented in magnitude — devising the thing without any basis. And even if, as he says, in his whole course of life he has done no offence against this constellation, surely he has now sinned more than enough, and even in his too-far-advanced old age has committed this offence (to speak as he himself does); and it would have been better to keep himself uncontaminated by this stain and blemish, lest he give others too just an occasion to complain of his absurdities — let alone that he, by protesting so frivolously and excusing himself, should complain or be disturbed at anything, as he does. But let these things be dismissed — to be received with laughter rather than with serious attention.

He next adds that, around the beginning of October, this Star was beheld by very many, both noble and base, learned and unlearned, and that it struck their eyes and judgments in a wonderful way. But I consider it in no way likely that this Star was seen by anyone in Italy around the beginning of October. Rather, this Raimondo invented it, in the liberty he takes of blurting out whatever he pleases boldly. For in all Germany, and in this our native Denmark, and also in the neighbouring northern kingdoms [Arctois Regnis], it was nowhere visible before the beginning of November — however very many there were who attended to celestial matters, and even among those who, whether for some office or for the sake of acquiring gain and a living, kept nightly watch by land and sea. And surely, if any star so brilliant had shone forth from heaven beyond the ordinary, it would by no means have escaped their gaze and their wonder. But if anyone wishes to object that, in the purer Italian air, and with the Pole there lower in its elevation,

the Star could have come into view sooner there than in this more northerly region of the world — to him I oppose, among many witnesses, this one testimony of that most excellent Mathematician Hieronymus Munosius the Spaniard [Jerónimo Muñoz], who without any doubt asserted that he had ascertained that this Star had not yet shone on the second day of November; and this not merely from the report of shepherds keeping their nightly watch over the herds, but confirmed by his own observation as well — since around those same nights, showing the Stars to his pupils, he nowhere caught sight of this one. And certainly the clearness of the air in Spain could be no less than in Italy [Ausonia], since it looks toward the south equally, or even, for the greater part, somewhat more. Indeed the elevation of the Pole at Valencia in Spain, where Muñoz resides, is more than six degrees lower than in the region of Venice, near which Raimondo was then living.

He says next that men have wrongly supposed this Star to be new, and have held varied, inconsistent, and erroneous judgments about it, because they have not — as the most skilled men, the followers of Ptolemy, and the illustrious Kings of Egypt once habitually did — diligently attended to the heavenly bodies. For (he claims), if they were in the practice of this, they would never have been persuaded that this Star was recent and not seen before; nor that it was a comet or a new planet — since before the creation of Adam it was created in the firmament along with the rest. And if all men were as expert in the Science of the Stars as those ancients, he supposes he would be relieved of the labour by which he set out to bring his opinion about this Star to light. But Raimondo ought rather to have pronounced this of himself than of others. For if he had had even moderate skill — to say nothing of as much as Ptolemy and the ancients in Egypt and elsewhere had — he would surely have distinguished the eleventh of Cassiopeia, which is in the upright part of the seat [in sedis erectione], more correctly from this very different new one: since they agree neither in position, nor in form, nor in magnitude, nor in colour, nor in respect of the arrangement of the others in the same asterism. For they stood apart from one another by at least one and a half degrees [sesquialtero Gradu], about three Solar Diameters [tres Diametros Solares]; and the magnitude of the Eleventh is reckoned of the fourth order [quartæ conditionis], whereas this New Star far surpasses those of the first magnitude [primi honoris]. Likewise, in the quality of light and colour there was an evident difference.

Yet it is not undeserving of approval, what he infers — that he might be excused from this labour, if the rest of mankind had as thorough a knowledge of the heavenly bodies as Ptolemy and the ancient Astronomers had. And rightly so. For

if that were the case, none of them would have attempted to persuade — or rather to impose upon — others that the New Star here in question and the eleventh of Cassiopeia were one and the same; or he would at least have done so in vain, and would have displayed his folly and gross ignorance at least to the common crowd, and would have served it up to be received only with jeers and rejection. And so it would have been far better, by keeping his hand from the table [*manum à tabula abstinendo*], to have refrained from this empty and superfluous labour.

As he comes closer to the matter, he promises to refute, by the most truthful arguments and the testimony of the most reliable authors, three opinions commonly held about this star. The first is that of those who supposed it to be a star recently brought into being — the one now under discussion — which had never before shone in the heavens, and that no other star had ever stood in the same place where this one was now seen. The second is the opinion of those who made it a comet. The third is that of those who called it a new planet. He says these three differing views had arisen three months earlier and had afterwards spread through various regions.

But here it seems to me that Raimondo [Annibale Raimondo] is not entirely consistent with himself as regards the star's first beginnings and the reports about it from various men. For he had written this around the end of the month of January of the following year; and if the talk about this star had grown among men a full three months earlier, then it was indeed around the beginning of November — not October, as he claims — that he first noticed it. He therefore overlooked the well-worn saying: that those who tell falsehoods need to have a good memory.

Now as for the two later judgments — those by which some men presumed to enter this star in the catalogue of comets, or to call it a new planet — even though it is beyond all doubt that they spoke things foreign to the truth, they are nonetheless not refuted by Raimondo solidly and adequately enough, so that there still remains occasion to keep the error alive. For comets do not always preserve the same arrangement with respect to the Sun, nor are they seen in the same disposition, nor do they display the same course or the same kind of form. Indeed, each of them is found to have something peculiar to itself; and some of them, it is recorded, have stood altogether motionless, though this happens more rarely. Now from the fact that this New Star differs from these characteristics, Raimondo has not proved safely and beyond challenge that the star was not a comet. Nor has he refuted by this means its waning in magnitude and the change

of colour which it seemed to have in common with comets — which he conveniently excused by the unsteady distemper in the air. And it is plainly false, the evidence he brings forward in support: that the stars of Cassiopeia [Cassiopeia] and of the Lesser Bear shone larger than usual when this New Star was seen growing brighter, and then together with it afterwards remitted their splendour. For what could be more idle and more remote from the truth than to invent this? And by what greater wrong could one do injury to the stars not only of Cassiopeia but also of the Lesser Bear — where, however, he clears himself at the outset — than by saying that they appeared more conspicuous in the customary way throughout all of November and December, and then together with this New Star suffered a diminution of their light and brightness? Yet this lay open to the eyes of no other people anywhere in the world.

If Raimondo alone — already a man in his seventies, his eyes dimmed by old age, and on top of that weakened in health, peering as it were through a lattice from the bedroom in which he was confined shut up on account of illness (as he himself admits), at least through a window — was nonetheless so sharp-sighted that he could see things that no one else anywhere in the whole world

could discern, even with the keenest eyes: then I consider this worthy of no less astonishment, or rather of disbelief, than that so tiny an eleventh star of Cassiopeia should have obtained so bright a light, on account of those spectacles of his which he holds out before us.

I do indeed admit that it sometimes happens that stars shine more or less brightly and present themselves unequally to the sight, and that this is because of the thinness or density of the intervening air, which often displays itself variously. But this does not persist for long, nor last one month or another: it occurs only by accident, and creeps in along with a corresponding change. Nor does it offer any very evident difference, provided that a calm and suitable clear sky has shone, and the light of the Moon has caused no hindrance. But it wearies me to go back over everything that Raimondo brings forward here, and to discuss all that he has scraped together here and there to establish his false opinion about the eleventh star of Cassiopeia. Let me say at least this much: if this New Star could be vindicated from the company of comets by no other reasonings than those he himself has brought, then it would still be a matter before the judge — whether it ought properly to be called a comet or not.

In just the same way, no less lazily and perfunctorily — indeed, insufficiently — he has attempted to establish that it was not a new planet, on the sole ground of its twinkling, by which it was very like the fixed stars. For it is not by this one

property that the fixed stars are distinguished from the planets — namely, that compared with them their light flickers with a twinkle — but they have many other things peculiar and proper to themselves, which are not found in the planets in the same way. Indeed, it is not entirely beyond controversy that the planets do not twinkle at all, since the star of Mars too is sometimes caught in this same wavering, on account of the peculiar nature of the air interposed. Had Raimondo said that the planets cannot, in the manner of the fixed stars, stand still in one and the same place of the heaven for several months (for otherwise they are called planets, that is, wanderers, because they shift their place from time to time, and are not undeservedly so named), and that this New Star did not cross the bounds of the zodiac as the planets do — that argument would have applied; and perhaps it would, far more probably, have established that this star was by no means to be reckoned a new and adventitious planet.

But leaving aside these two fruitless speculations and fictions — by which certain men, equating this star with comets or with planets through their imprudence, detracted greatly from its genuine and true nature (since this question, moreover, holds no great ambiguity, and has been amply decided elsewhere) — let us rather examine what Annibale of Verona [Annibale Raimondo] sets against the first assertion here: the assertion by which this star was judged to be plainly new, as in truth it also was. And let us see whether the old Annibale of Carthage, who once wore down the Romans and almost all of Italy by his own strength, could attack and weaken that assertion as forcefully as this one.

He says that he openly denies (would that he did not at the same time deny it most ineptly) that the star we are treating of was New, and not seen by the heavens before. For,

what he alleges — that there is no one of sound judgment, well versed in the forty-eight Images of the Firmament, who would not freely admit that the star held by many to be New is old, and one of those that have remained perpetually fixed in the Throne of Cassiopeia — the matter in fact stands quite the contrary way. For the more skilled anyone is in the knowledge of the stars, the less he will assent to this assertion; while the more ignorant and stupid he is in judgment, and the less practised in this arena (such as this Author shows himself to be, not at all obscurely), the more readily he will subscribe to so empty and idle a fancy as this man has dreamed up.

And so Raimondo, wishing to persuade everyone — or rather to throw dust in the eyes of the more unskilled — of what would seem to no one else who understands the matter even in any plausible way, and not wanting them to suppose that he

himself was ignorant of the number and position of the stars of Cassiopeia, and to speak as though blind about colours (which, however, he did do rather insolently) — Raimondo undertook, from the Abacus and the Alphonsine numbers, to recall the thirteen stars of the asterism of Cassiopeia, noted by the ancients, to the fifth day of October, on which he pretends the star first shone forth (indeed, to the hour 1½ of the following night), and this, moreover, with allowance made for the meridian of the city of Venice (O empty and useless subtlety!) — by no slight labour, to be sure — and to inscribe them on the Pillars of Hercules. Now in marking down the positions of these fixed stars from the Alphonsine reckoning, he committed an error not of slight moment, an error of precession: but the heaven itself — which would have been more fitting (since he wishes to be held so great an astronomer, and to be likened to those ancients) — he did not take into counsel. And if he had done this, or had ever learned in what way the task was to be approached, he would not have assigned to the stars of Cassiopeia places so incongruous, trusting only to bare papers and to the erroneous Alphonsine reckoning, both in longitude and in latitude. How easily this could be shown, by comparison with our own work in this matter — the work which we have drawn down from the heavens — set forth from the second Chapter of this Book, and to be taken especially from near the end of the same, will not be difficult to make plain.

And yet, even granting that the positions of the fixed stars, as he has assigned them, were rightly established, would it on that account follow that this New Star — which has been observed in none of those places — was old, and was one of these very stars? To prove this, nonetheless, he takes refuge in the testimony of the senses of the eyes, supposing perhaps, according to the Maxims of the jurisconsults, that an eyewitness counts for more than ten who report by hearing. This he would not do without good reason, provided only that he did not abuse the very senses of the eyes and set up things contrary to them, on a testimony by no means authentic and indeed fallacious. For while with rods (as he calls them) he measures the mutual distances of the stars of Cassiopeia from the Pole Star, and estimates the matter by ocular intuition alone, without accurate observation, he both loses and brings forth the truth — which is not everywhere obvious to a first glance — bringing it forth, so to speak, by a kind of conjecture made with rods.

For this New Star could in some manner be seen near about the same place where that eleventh star of Cassiopeia stands — the star which he wrongly takes it to be — and not very unlike the other stars of Cassiopeia, especially the three brighter ones which he afterwards marked in his figure as set crosswise. It might,

when one weighs up the arrangement it obtained — in a broad way, namely, as he did (whether through ignorance, or through age and the worsening of his illness) — be taken for it. Yet, if accurate sighting were applied, this New Star would by no means be allotted the same placement, relative to the Pole Star and to the rest in the asterism of Cassiopeia, as the said eleventh star of Cassiopeia. For it stood apart from Cynosura by nearly $25\frac{1}{4}$ degrees, whereas the eleventh is removed from it by 26 degrees, and by just as many minutes: a full degree and $\frac{1}{2}$ more. This is plain from the reliable observations recited in Chapter 4. Nor again did this New Star form so obtuse an angle with those three brighter stars of Cassiopeia — namely the second, fourth, and twelfth — as that eleventh did: as can be seen from the depiction in our Chapter 3. Moreover, by a sufficiently evident interval, the New Star was separated from the eleventh, toward the south especially, by the amount of one and a half degrees, as I noted before. And what most of all betrays Raimondo's gross ignorance and hallucination is that the eleventh itself, from the very first appearance of the New Star, lay perpetually open beside it in its own genuine place. From the beginning, to be sure, it was discernible only by those who were keen of sight and well acquainted with its place, on account of the New Star's great size and the splendour of its light, which obscured this tiny one near it (as happens elsewhere when the brighter planets come into closer conjunction with smaller stars). But as the New Star gradually waned and remitted the brilliance of its light, this eleventh shone out more and more, and was seen close beside it under a clear sky — even by those whose eyesight was not very strong — and especially when the Moon was hidden, it appeared not obscurely.

And I have no doubt that this was the occasion of Raimondo's so blind an error: that, with eyes dimmed by old age and infirmity, he could not make out this eleventh star — which is at least of the fourth magnitude — at the time when the New Star, around the first beginnings of its light and with the vigour of its rays rather strong, was in full force; nor distinguish it from this recent one. And so, taking the one for the other, he wrongly contended that the New Star was the old eleventh one and no other; and from there he asserted too boldly that, at the great distance of the heaven, there were no stars of any kind, from the first magnitude all the way down to the sixth — except the fourth and twelfth of Cassiopeia — anywhere near this New Star: and he appeals to those whose eyesight was strong. So then, if Raimondo, because of the dullness of his eyes, was unable to discern that eleventh star which was near the New One (though it lay open not very obscurely), he might at any rate have learned from younger men, more strongly endowed with keenness of sight, that it was indeed present there — provided that some

held back by some attachment to the truth, and had not deliberately set out to seize upon this opportunity and to belittle so great a prodigy.

To support his further claim that this recent star is the old eleventh star of Cassiopeia, he relies on the difference in declination of this star from Cynosura [the Pole Star]—which he wrongly calls a distance (for him it is $25^{\circ} 58'$)—asserting that it agrees with the eleventh star alone and is shared with the New Star, and on that basis he pronounces them one and the same star. But if he had properly learned to measure the intervals between stars, he would have found that this New Star stood $25^{\circ} 14'$ from the Pole, while that eleventh star stood $26^{\circ} 26'$ from it. These plainly do not coincide in one and the same point. And if we choose to bring in the difference of declinations as evidence, the result for the difference between the Pole Star and the New Star is $25^{\circ} 13'$, but for the same star and the eleventh star it is $26^{\circ} 26'$. The difference of declinations here agrees so closely with the actual interval between the stars because the discrepancy in right ascensions was not large—otherwise Raimondo [Annibale Raimondo] would have used the one for the other to no purpose.

Furthermore, as to his claim that no other star (as he says) was there, one ranging in longitude from the fourth degree of Taurus up to the seventh, with a declination reaching 62° , apart from that old eleventh star, which he places in Taurus $5^{\circ} 18'$ and to which he assigns a declination of $60^{\circ} 13'$ —these figures simply do not hold up on their own terms. For the longitude of this little star was at that time Taurus $6^{\circ} 42'$, one degree and one third [$\frac{1}{3}$] beyond its [stated] reckoning, which he borrowed from the Alphonsine calculation [Alphonsine Tables]; and its declination was $60^{\circ} 34'$, which exceeds his own note by $21'$. Yet if he had reckoned this correctly from the Alphonsine figures, he would have come closer to the mark, within six scruples [minutes] at the least—as is clear from the calculations we set out near the beginning of Chapter 5, in the Alphonsine computations of the stars of Cassiopeia. This New Star, however, as has been shown repeatedly in that same chapter, stood at Taurus $6^{\circ} 54'$, and therefore lay $12'$ farther in longitude than the eleventh star; and it had a declination of $61^{\circ} 47'$. It was thus $1^{\circ} 13'$ more remote from the equator than the aforesaid eleventh star.

Those in Italy who fixed the longitude of the New Star at Taurus $6^{\circ} 20'$, together with a declination of $61^{\circ} 40'$ —as he reports—advanced its longitude by more than half a degree. In declination, however, they erred by scarcely seven scruples [minutes], and so they made it closer to the eleventh star than was warranted. Yet from this Raimondo gains no support at all. For in reality this eleventh star stood at a distance of one and a half degrees from the New Star—however

presumptuously he may deny it, his sight clouded partly by failing eyes and partly by faulty judgment, so that he was unable to see, and to admit, the actual state of affairs.

In vain, therefore, does he conclude that the New Star had the same longitude, latitude, declination, and distance as that old eleventh star, and so was plainly identical with it—on the grounds that two bodies cannot occupy one place. But the premise he assumes is utterly false, as is clear from what has been said. By no means did this New Star share all the things he reports in common with the eleventh; on the contrary, it shared none of them. And so it was not the same star, but another, different from it. It had its own place to occupy, free of any interference from the other—at a distance, as has been said several times, of very nearly one and a half degrees. There is thus no need to posit anything absurd, as though it were necessary that two bodies be set in one place, which—on his false claim—would follow.

Next he calls on the testimony of Hyginus, who left the following written: *In the Quadrilateral, where the figure [of Cassiopeia] is delineated, in both angles single stars shine more brightly than the rest.* From this he tries to infer that the eleventh star of Cassiopeia, set in the corner of the seat, shines more brightly than the rest of the stars in that constellation. But this is utterly false, as is plain enough to anyone who has up to now looked at that eleventh star. For this star, in that Quadrilateral of Cassiopeia with its unequal sides, is the smallest of all, since it is at most of the fourth magnitude, whereas the other three are of the third order and hence far more brilliant. Nor in fact do the words of Hyginus mean what he twists them to say. Rather, the reference should be understood of those three brighter stars, namely those in the breast and those alongside the flank and the top of the seat [Catheda]—because these shine more clearly, if indeed Hyginus meant to hint at any such thing, and if the text here is not faulty and corrupt. For he hardly seems to express what he meant to say. He also introduces a different arrangement of the figure of Cassiopeia with its seat than is otherwise customary, and he does not set out its stars exactly as they are seen disposed in the heavens themselves—whereas the figuration of Hyginus, when applied to the one we drew in Chapter 3 directly from the sky, becomes clear at a mere glance, even to one who looks only in passing. But why not rather consult Ptolemy [Ptolemy], who rightly assigned to this star a designation of the fourth magnitude, in agreement with the heaven itself?

For all these reasons it is abundantly clear how absurd, empty, and frivolous are the claims Raimondo puts forward in maintaining and trying to persuade us that

the New Star did not shine forth, but was the old eleventh star taken for it. Yet by this exceedingly foolish and rash opinion he led many in Italy astray—especially those who had no sure knowledge of any other heavenly body—and drew them, without just cause, to his side. So, when I entered Italy three years after the star's appearance, I heard, not without distaste, that very many were still imbued with this opinion: that this star was not new, but some old one accidentally illuminated. So true is it that an error, once it has invaded the minds of men and fixed its roots, is only with difficulty rooted out of everyone; rather, in some it clings on, in part if not wholly, for a long time, even after Truth itself has been shut out and driven into exile.

And since he could bring forward no sufficient and probable reasons by which that little star should have been lit up with so great a majesty of light beyond its usual state—except that something similar had happened to the rest of the stars of Cassiopeia,

which was nonetheless wholly false—he resorted to pretending that the eleventh star of Cassiopeia had perpetually been brighter than the rest. And this he wrongly alleges, out of sheer ignorance of the stars, on the authority of Hyginus at least—whom he cites in vain on his own behalf, corrupted or poorly understood as that author is—insolently mocking those who assert truer things, when the heaven itself has displayed this star as being at most of the fourth magnitude for so many ages now. For that reason, recklessly, he published yet another writing on this very matter, to prop up his earlier ineptitudes and to render them more plausible. This little treatise, composed in the Italian and his native tongue, he entitled as directed against a certain other man who had maintained that this star was a comet. And although there he does defend, not without just cause, the title of comet wrongly attributed to it (provided one knows how to distinguish and define such things rightly), nonetheless those who held this star to be of the nature of some comet, yet placed it among the ethereal seats of the world, seem to philosophize on this matter far more rightly and soundly than Raimondo. Such was that most excellent man, Muñoz the Spaniard [Jerónimo Muñoz], who, following the opinion of the oldest philosophers on comets—that they were ethereal—held it to be a certain peculiar comet of the eighth sphere [Octava Sphaera]. Their only fault is that, in too broad and improper a manner, they apply the name "comet" to any phenomenon whatever, even to one most like a genuine star, and far removed from the usual form and condition of the long-haired stars [comets]. But since the matter itself is settled, there will be no laborious dispute about names. Yet for the sake of clarity and

propriety, words that express the peculiar nature and essential form of things should be chosen, embraced, and rightly applied.

Now, in this second writing, in order to cover over his earlier and exceedingly foolish assertion with some show of plausibility—lest he be convicted of too gross an error—he seized, as a screen, upon certain dry, smoky vapors, which he invented as having been drawn to this star (which is in the seat of Cassiopeia, as its eleventh star) so that, with these interposed, it might appear larger than usual. For since this star is by itself at most of the fourth magnitude, and does not strike the eyes very plainly, whereas the New Star—which the whole world then beheld—surpassed not only all the fixed stars, even Sirius [Syrium] and Lyra [Lyræ], but also the brilliant star of Jupiter [Iouis illustre Sidus], and very nearly Venus [Venerem] herself, in apparent size and in dazzling glitter of light: to imagine some famous and smoky medium of this kind is surely contrary to all truth—the means by which, beyond the established habit of all the stars that have shone in the whole heaven up to now, this tiny star of Cassiopeia should be thought to have grown to such an excess of body and light as it plainly had for all to see. And in order to make this very notion—emptier and more frivolous than smoke—appear more probable, he supposed that the other stars of Cassiopeia and of the Lesser Bear [Ursa Minor] were likewise covered over by these same smoky vapors, and were thereby rendered

more brilliant. He contrived and dared to publish—against all truth—that this eleventh star was in fact rendered more brilliant than all the rest, on the grounds that the smoky vapors had thickened and condensed more densely beneath it than beneath the others. Indeed, he even fabricated that some little stars of Cassiopeia, which had earlier vanished from sight because of their faintness, now appeared more conspicuous for the same reason—when in fact nothing of the kind happened, neither in any stars of Cassiopeia or Cynosura nor in any others whatsoever, during the time of this New Star (unless, as does happen, occasionally by accident, and even then not for long). For by no means was any of them seen larger or brighter than usual—unless perhaps, when the Moon was below the horizon, in some thoroughly purged clearness and cold of the air, such as occurred this past winter when the New Star first shone forth. It then happened that the stars (as also happens at other times) thrust themselves with their twinkling light upon the eyes, and lay more open to view; so that the smaller ones, which at other times are very hard to make out, were then more readily discerned. This happens every winter, sometimes more, sometimes less, according as the air is made rarer or denser, which more intense cold brings about.

But lest these things should be thought to have been declared without authority and endorsement, he summons the agreement of Ptolemy from Chapter 13, and finally from Book 2 of his *Quadripartite* [*Tetrabiblos*] in testimony—on the strength of a place where Ptolemy says: *Whenever we observe the fixed stars looking like little crowds, that is, [varying] in color or in magnitude, then, if they appear brighter and larger than usual, in whatever quarter of the sky they shine, they will stir up winds from that direction.* From these words of Ptolemy, perversely alleged in defense of his own opinion, he will by no means establish that Ptolemy meant that any stars, gathered out of the smoky vapors massed beneath them, could for one month or another, or for longer, appear in a more brilliant form, larger, and persist in such an aspect. For Ptolemy is here speaking of a momentary quality, as it were, of the air, sometimes charged with certain dry exhalations, which makes some stars appear brighter and larger than usual. And at that time, when these exhalations are drier and supply matter to the winds, they are the harbingers of those winds; and so something of this sort, somewhat altered and magnified in the appearance of the fixed stars, is shown to us. Nor indeed is Ptolemy here speaking properly of all the stars, although this sense can in some way be stretched to any of them, and a place for it can sometimes be found among the rest; rather, he understands only those that present themselves, as it were, as little crowds, and at the same time seem clustered together—such as the Pleiades, the head and sword of Orion, the misty whorl of Cancer, the Coma Berenices, and any others of the kind. For when these tiny and at the same time clustered stars are seen more conspicuously, it is a sign that the intervening air is affected by certain dry and transparent vapors, which easily resolve into winds. And since the generation of these smoky vapors is swift and unstable, and does not long persist in the same condition, but is subject to dissolution and alteration almost from hour to hour—as is also clear, not obscurely, from the Ptolemaic text itself, when he says:

on whatever quarter of the sky they shine from, the winds are to be expected to come.

But who does not know that the stars—especially those around the Zodiac and the equator—all run through every quarter of the sky in any horizon within twenty-four hours? If, then, in one quarter they shine more brightly than in another, this must (on his account) happen because of dry vapors being engendered there by winds destined for that region. Yet these vapors plainly take on, together with those very winds, a shifting and almost instantaneous character; nor do they accompany the stars when these are carried by the motion of the universe into another part of the sky. For the vapors have no connection

with the stars; they merely linger for a little while in the air, and indeed in some particular region and quarter of it. Since, I say, these vapors display themselves so variously and are more changeable than Proteus himself, by what just reasoning, I ask, could anyone drag them in to account for this remarkable—or rather fictitious—brightening of Ptolemy's eleventh star of Cassiopeia? From this it followed that the preeminence of light and brilliance which the New Star (which he wrongly takes to be the eleventh) gave off surpassed the stars of the first rank for two or even three months, indeed for nearly a whole year; while the eleventh star, which is of the fourth magnitude, was seen to be outshone. And in November of the year 1573 the New Star at last appeared equal to this one.

It would therefore have been necessary for those dry smoky vapors, which (on Raimondo's view) afforded this eleventh star a fuller light, like a magnifying glass, to have lasted for very nearly the whole year; to have endured constantly the changes of summer as much as of winter; to have revolved, equal to one another and to the star itself, and nowhere deviating from it, around the pole through every quarter of the sky in step with it. How utterly remote this was from Ptolemy's view, which Raimondo cites, as well as from all truth! And how could it come about that vapors of this sort would heap themselves together beneath some one particular star, and yet not reach others in its vicinity—especially if they were to last any length of time—seeing that they cannot be confined within fixed bounds, being made of fluid and wandering matter? Or again, why did they not at some point during so long a time at least reach that true eleventh star, which was not two degrees distant from the New Star, and make it more luminous?

It must also be noted that, although Raimondo declared in his earlier treatise that no star could be found so near the place where the New Star blazed forth as could be reckoned the eleventh and take its place—and that therefore the eleventh and the star thought to be the New Star were one and the same—now, after either he himself noticed it, or learned of it through the warnings of others, that the little star which he had earlier lost was being seen again in the sky, as the brightness of the new light diminished and granted a now better view of it than at the beginning (when it was obscured by the presence of the greater light), he tacitly corrects himself in a manner, and admits that there was a certain other small star nearby. Yet he makes this star so different from the eleventh that he still persists in the error by which he had taken the eleventh for the New Star—or rather denied the New Star in favor of the eleventh—and clings to his purpose; and so one falsehood props up another. For let him

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—let anyone who wishes look at the sky, even with eyesight of the keenest acuity, on winter nights when the air itself is perfectly clear, while the very frost forces the brilliance of the stars more strongly upon the eyes and thins the breeze, and the moon's rays are not in the way; he will assuredly behold no other star, however tiny, near the eleventh, that could be taken for it. For in the whole constellation of Cassiopeia there occurs none nearer than the one that lies in the bend, beside the flank, of the third magnitude—as anyone may recognize even from the bare inspection of its delineation, which we set out with careful diligence in Chapter 3. Indeed, beyond the 13 stars of Cassiopeia assigned to this asterism by the ancients, we have fitted in 13 others, which could at least to some extent be made out in it under a clear sky—so that none, not even the smallest, that lay open to view has been passed over. If anyone should distinctly perceive others as well, and more of them, he will be able to mark them down there and to count them—and prove it not by words but by the thing itself, and bring out their positions from the heavens, just as we have done, by means of suitable instruments. I will not, however, deny that there may be no others at all there; but if there are any, they will display themselves with so faint a trace that they could scarcely lie open even to direct ocular vision, much less to instrumental measurement—so much so that they would repel the keen edge of youthful eyes, far more the foggy dullness of Raimondo.

As for what he further infers—that his eleventh star was therefore not new, because it was successively rendered smaller in light and quantity—this does not tell in his own favor. On the contrary: had he said the opposite—namely that the Star which was seen to be New gradually lost its light and quantity, and so was something unusual and foreign to genuine stars, since this befell neither the eleventh nor any others among the Fixed Stars in the heavens by their nature (the planets alone excepted, in whose case it arises from their approach to and recession from the Earth, which follows from the hypothesis of their motion)—he would by all means have brought forward a far more fitting censure.

But it is supremely ridiculous and superstitious that he does not hesitate to attribute free will to his empty smoky vapors—just as with most of the other things he brings in here, which are of no weight and, by reason of their excessive vanity, do not deserve refutation.

Finally, in order to excuse the so steady and long-lasting brightness of the Star by some at least specious pretext, he pretends that his smoky vapors flew up into the highest region of the air, and there stood motionless, and on that account

afforded a supply to the increasing light. But although it may be granted that certain vapors, especially the drier ones, can sometimes rise higher than the moister ones, and above the region of the winds; nevertheless, even if they are not there driven about and dispersed by winds, on account of the natural fluidity and inconstancy of their own nature, and of the matter of which they consist—its lightness—they cannot remain long in one and the same place, but seek out one shifting form and condition after another, until they wholly vanish, entirely consumed.

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Nor could they hold themselves in the same tenor and place for long, given the most rapid agitation of the air, which is believed to follow the universal daily motion. I pass over the fact that, if that highest part of the air—drawing near, as it does everywhere, to the fiery element (which Aristotle, that Prometheus of the Academics, falsely substituted for the moon) and being (as is supposed) of a more burning nature—then these dry exhalations, having there caught flame, would, when the matter was consumed (since no other was at hand to supply fuel), quickly burn out: just as happens in comets, which arise from that same Aristotelian workshop, and which inveterate error has long fooled very many. But in truth, those who grant that smoky exhalations of this sort rise into the highest air have not looked closely at what has been demonstrated by writers on optics—Alhazen [Ibn al-Haytham], and his imitator Witelo, and in our own age also by Petrus Nonius the Spaniard [Pedro Nunes] in his book *On Twilights*—namely, that no vapors at all, even the thinnest, which could fall upon the senses or thrust the appearance of any spectacle upon the eyes, rise higher than 52,000 paces, or—what comes to nearly the same—12 German miles. For otherwise the twilight, both at dawn and at dusk, would last longer than experience shows, since those vapors, owing to their higher position, would catch the light of the Sun sooner in the morning and longer in the evening, and would impart that light somewhat to our eyes. Those, therefore, who believe that vapors can be carried higher up, believe it without firm demonstration—indeed against all experience: they suppose it rather than know it. And although someone might judge that this could at some time come about through the force of the heavenly bodies, yet that it should endure long in the same substance and condition, and should not be illuminated by the Sun at night-time, when the visible horizon offers no impediment (which, given their great elevation, is the more readily granted), and not at all be seen by us—this he will by no means obtain.

I will add this too: that whereas Raimondo, in his earlier treatise, abstained from all prognostication—because, namely, he judged that nothing new had arisen in the heavens, and that therefore nothing was foreshadowed by it—now, nevertheless, in this second one he appends predictions. These would indeed be frivolous even here, if they were being sought from dry smoky vapors that (as he dreams) make some star brighter. From these, if it had pleased him to follow Ptolemy in divination too—Ptolemy, whom he brought forward on his own behalf from the outset—he could have predicted nothing other than more violent gusts of winds, and conjectured a few outcomes that sometimes arise incidentally on land or sea; and so he would have been consistent even with himself by not laying bare his vanities in this part either. But I am unwilling to take note one by one of all the things in Raimondo's notions—more inconstant and more evanescent than the very smoky vapors he has devised—especially since his utterly empty fabrications have already before this been depicted in their true colors, and refuted, fully and more than fully, by that most distinguished man, Dr. Thaddaeus Hagecius [Tadeáš Hájek], both in his *Dialexis* against him and in certain particular pamphlets published against the same man. For however much Raimondo, in defending biting-

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—biting-ly an opinion once wrongly seized upon, and in vindicating it from Hájek's objections, labored with contrary writings: yet he accomplished nothing else than to display publicly his own obstinacy, ill will, and perverse judgment, together with a gross ignorance in matters of astronomy. For he did not repel the weapons cast against him with solid and unconquered supports of sure reasoning and observation, but at best pleaded his cause buffoonishly with gibes, abusive talk, cavils, slanders, and quarrelsome and shameless wranglings; and to bespatter and drag down—undeservedly, and with malice—the reputation and good name of that excellent, wholly upright, and praiseworthy man, with many reproaches and insults, he did not blush, with more than a kind of canine rage and excessive impudence. And so, by these obstinate and virulent disparagements of his, by which he did no slight violence and injury both to Truth and to Hájek himself, he provoked this man—otherwise moderate and desirous of tranquility, and sincere, without prejudice toward the labors of others—to such a degree that, not only did he beat back and refute Raimondo's responses to the matters themselves, which were empty in themselves, but, forgetting even his own self, he was carried somewhat more sharply than usual, beyond his customary moderation, in turn against him—when it might perhaps have been more advisable to have looked down on most of it from on high, and to

have deemed it, as insipid, empty, and maliciously fabricated, worthy of no response. Of this too I once admonished Hájek, when we were together for a time at Regensburg. But a just resentment, on account of the excessive injuries inflicted, sometimes rouses even more modest and gentler natures to vindication. For to assert the truth, to protect one's reputation and good name, to repel others who attack it—this is naturally implanted in men who rest upon a more prudent disposition and a good conscience.

But what is comprised in those antagonistic writings I am unwilling to examine one by one, and to pass censure upon—since, beyond what has already been said, it would contribute little to the matter we are treating, which still has to be further confirmed and illustrated. They have been published openly: let whoever wishes inspect, read, and judge them. The matter is sufficiently clear in itself, and has no need of many disputes or contradictions: namely, that a New Star shone forth from heaven, different from the eleventh and from all the rest of Cassiopeia; and that no smoky vapors whatever contributed anything here, or furnished any occasion for this. Whoever have thought otherwise have wronged the heavens themselves and most evident Experience, and have impiously and shamelessly belittled so exceedingly and beyond measure admirable a token of the Divine Majesty, displayed in this age of the world to the dwellers on earth.

But since these Raimondine smoky vapors have had the power to obscure the truth with so gross a darkness, and to blind the senses of the eyes and the judgment of the mind in most people, so that they could not tell right from false—and since, those vapors not yet being sufficiently dispelled and refuted, those too greatly seduced into this opinion may perhaps still seem to be in the right: therefore, before I put an end to this inquiry, besides the physical reasons given above from the very nature of vapors—namely, that

they do not rise so high, nor last so long, nor are they able to accompany the Star uniformly throughout its whole revolution—and so on. To these one may add the following. If the Star's light, made to radiate and gleam continuously through thickened vapors—however dry and transparent—could not be transmitted to us in a uniform manner, then there would be no continuous twinkling, especially while that smoky medium itself remained at rest; and it was precisely this medium that they supposed had increased the Star's light for us. For granted that the Star did appear larger as a result, yet its light would have been refracted and dulled, turbid rather than sparkling and clear, and it would not have presented itself to the eyes—at least, not if those smoky exhalations were rather dense; for if

they had been so, they could not have been altogether clearly and crystal-clear in their transparency.

Besides these arguments, I say, and others drawn from the genuine nature of terrestrial vapors—arguments that no observer and student of natural things will easily deny—I shall now add still others, derived partly from optics, partly from the unconquerable demonstrations of geometry, which will lay bare Raimondo's [Annibale Raimondo] follies still more fully.

The optical argument proceeds from the property of refraction, which is as follows. When some luminous body is viewed through a transparent medium denser than the one set between it and our eye, it must appear refracted—and therefore in a different place, somewhat higher than it really is. This displacement is greater or smaller according as the body is nearer the vertex of the head or, on the other hand, slopes down from it toward the horizon. Thus when a body is directly at the zenith, the line of sight is not subject to refraction; but the closer it comes to the horizon, the more the refraction itself, and the apparent departure from the true position, is increased. One may learn this from several theorems in Book 10 of the *Optics* of Witelo [Witelo].

Now suppose, then, that the eleventh star of Cassiopeia—let us imagine for the moment, with Raimondo, that it was the one we are speaking of, the new one—was turning high up near the vertex, passing through intervening vapors: it would undergo no very perceptible refraction, and its true place would very nearly coincide with its apparent place. But when it was at its lowest altitude, close to the horizon, an evident refraction would have crept in, so much so that it would have been perceptibly seen higher than was just; and it would come about that at its highest altitude it would be removed somewhat farther from the pole, and at its lowest somewhat less—a difference quite perceptible. For if those vapors were of such efficacy that they could display the Star, on its own account at least of the fourth magnitude, like Sirius [Syrius] or even larger, presenting it to view in size and light, how much more would they have notably suggested to the eyes its refracted place, tending farther toward the upper region! When the Sun rises over the horizon, even in the most serene sky, on account of the very thinnest vapors it acquires a refraction of half a degree (as repeated experience has taught us) and appears just that much higher than it really is—so much so that when it seems to have only touched the horizon with its lower limb, its whole body is in reality sunk below it. And although the Sun then appears somewhat larger than at other times around the meridian, yet that difference is not so great, nor...

to be set down to the diversity by which, on account of refraction, the place presents itself otherwise to sight. What I say of the Sun holds in almost the same way for the Moon and the other stars, occurring with only a slight difference. The eleventh star of Cassiopeia, then, ought to have been refractively lifted up—if the vapors or smoky exhalations had been great enough, and its body so much enlarged—still much more, and especially in its lower position, away from its genuine place. So that this aberration of sight would, at the very least, have exceeded half a degree (if not a whole one); by which interval, too, it would have been brought nearer to the pole than was just. And in its upper position, even though this refraction would be very slight, yet whatever it amounted to, it would have moved the Star somewhat farther from the pole than it ought. Therefore it would follow that its declination would plainly turn out unequal, taken in both ways, above and below the pole—greater here, smaller there. Yet the accurate observations made on the New Star by no means allowed this: they exhibited the same distance of it from the pole in both positions, as is clearly evident from what we set forth in Chapter 6. The observations of the Landgrave's people [Landgravians] likewise, which in the lower position drew the Star three minutes farther from the pole, support this assertion all the more, and refute Raimondo's fictions all the more. By no vapors, then, was the eleventh star of Cassiopeia seen to be increased in body and in light. Therefore this could not have been the same as that New one we are discussing; but it truly offered itself to be seen as a certain new Star, sent from the heavens, without any interposition of an intervening medium, and without that falsely insinuated illumination of the eyes. This is what we meant to show by the present optical proof.

Geometrically, however, the same thing is made clear as follows. Those smoky exhalations which Raimondo imagines to have increased the light of the Cassiopeia star must necessarily have been below the Moon, in the elemental region. For who, having so much as tasted philosophy with the tip of his lips, would ever believe that terrestrial vapors enter and contaminate the ethereal world?—or, if that were granted, that they could remain there long without being scattered by the light and force of the stars and by their most violent motion? Therefore if these dry fumes existed below the Moon, and nonetheless occupied no more space than would suffice by their thickness to cover the eleventh star of Cassiopeia alone, and were carried round together with it, then that revolution which the fumosity produced must necessarily have had the axis of its circuit either on the Earth's surface or at its center. If on the surface, then it could not have been interposed in the same way before this Star and our sight in every horizon; if at the center, then in one and the same horizon this could in no way occur alike in the higher and in the lower position—because of the perceptible

proportion of the Earth's semidiameter with respect to the remoteness of those smoky exhalations, since the Moon herself is not so far off but that, for this very cause, the Sun is not everywhere covered in the same way in...

an eclipse: and it happens in different ways for one position or another in the diurnal revolution. All these things are sufficiently plain to those who understand this art, if only they will weigh them with some consideration—so that there is no need to explain them here by a longer demonstration and diagram.

There is also this to add: that little star of Cassiopeia would not, on account of those dry intervening exhalations, have appeared everywhere over the whole globe of the Earth so splendidly, nor—if this New one had stood under it alone, and had not touched in like measure the others neighboring upon it—would it have increased their light in an unaccustomed way. This last point has been excellently and skillfully demonstrated, on geometrical grounds, by the most excellent philosopher Giovanni Battista Benedetti, a patrician of Venice [Giovanni Battista Benedetti], in that distinguished Work which he entitled *On Mathematical and Physical Speculations* [*Diversarum speculationum mathematicarum et physicarum liber*], near the end, among his Letters, clearly and lucidly. Writing there to this same Annibale Raimondo, he plainly shows the absurdity that necessarily follows from Raimondo's false assumption. But since this book of Benedetti's may not perhaps be ready to hand for all who need it, I shall add his own words and his Demonstration, just as he there resolved the knot of the question proposed to Raimondo.

I shall do this the more willingly so that it may more readily be established—what we said at the outset—that there were, among the foremost men of the Venetian Republic, even in the chief families, those who would not find it difficult to understand that the things being foisted upon them by Raimondo were in no way consonant with the truth; and so that he may have the refutation of his follies from a fellow-countryman of his own. This I am pleased now to subjoin, as a sort of Coronis [closing flourish], to our own censure of Raimondo's positions—not because it needs anything (since on its own it stands wholly correct and is geometrically satisfactory), but so that, in that distinguished and most polished elaboration of his, it may be set forth fully refined; this I shall add. For granted that he establishes the semidiameter of the elemental region, in imitation of Ptolemy [Ptolemy], to be at least 33 of the Earth's semidiameters—whereas someone might suggest a doubt about this, since Copernicus [Copernicus] found the same to be 52 semidiameters, which is in fact nearer the truth—yet Benedetti's intention is not much disturbed on this account. For up to a height of

33 semidiameters, that any exhalations rise—not even Raimondo himself, however much he teems with smoky vanities, would admit, much less anyone else who has philosophized rightly about these matters: since it is in itself incredible and plainly impossible, optical reasonings too disapproving it not obscurely. Now therefore I shall subjoin the Letter I promised, word for word, taken from the aforesaid book of Battista Benedetti, together with the drawings of the Demonstrations which the Author himself assigned. Then I shall turn my pen to the others who passed judgment on this Star far too incompetently. From this it will be evident (as I said) that these things so concisely and skillfully savor of geometrical truth, that no doubt of any moment can remain.

After I had read through your most learned writings and considered them, [I judged] that if, from a multitude of exhalations in the elemental region, it had come about in the year 1572 and 1573 that for six whole months that Star was seen by everyone throughout the whole globe of the Earth—standing in the northern angle of the Quadrilateral of Cassiopeia, so bright that it glittered more ruddily than Lucifer [Venus, the Morning Star] himself, and twinkled (without any difference of aspect) more than all the rest—how could it be that the stars not far distant from it, though otherwise much larger, did not also appear brighter? But if someone should say that this exhalation was perhaps not so spread out that another star might be interposed between it and us, then I would answer that it must necessarily follow that such an exhalation occupied so great a breadth—because it would make some other star, neighboring it for some peoples, brighter (the very star of which we made mention)—. But since this was perceived to hold for none, it followed that that light could not arise from those elemental exhalations themselves: for that twinkling of it was the greatest indication to us, if it is right to believe it; since the more some celestial body twinkles, the farther it is from us.

But since you have insistently demanded of me that I write you something concerning the speculation of this matter, therefore, wishing to comply with your wish, I subjoin a few things.

Consider first this first figure drawn below, in which C A E is set down for the terrestrial Globe, whose center is I, and V O N for the convexity of fire; but K X S for the eighth Orb, and X for the Star already spoken of above—which always was, is, and will be, although it is now somewhat more obscure than the other three. Take next two places on the surface of the Earth, namely C and E, diametrically opposite each other, such that around their horizons it is possible for the Star X to be seen—by the rays of those stars' midheaven X N E and X V C,

whose parts N C and V E are so short with respect to their wholes that scarcely one part in six hundred thousand is one of the parts of ten thousand, as you know. It follows that the straight line bounded by V and N is not perceptibly smaller than the Earth's diameter C E itself, since these two intervals stand to each other from the similarity of the Triangles as X I to X O—that is, very nearly as 602 to 601. Whence the angles N E C and V C E will be seen to differ not at all from right angles, since their difference is in a certain way least. Then, when the two diagonals E V and C N have been drawn, they will terminate the angles N E V and E N C nearly equal to each other; the same I assert of the angles V C N and E V C.

Suppose now, first, that your sublimated exhalation reaches to the highest parts of the elemental region, round about the line O I: then it would be clear that, if by reason of such an exhalation the Star X were seen so bright both to those looking from E and from C, the exhalation could not be of smaller breadth than V N—that is, than the Earth's diameter—since the same is nearly equal in length; but the point V can well enough be seen by the eye at E, and the point N by the eye at C, as I have proved to you elsewhere, by reason of the refraction of the rays passing through different transparent media. Now when these two rays E V and C N have been produced as far as the eighth Orb, to the points S and K, it will remain for us to see the quantities of the degrees of the arcs S X and K X. But S X subtends the angle S E X, and K X the angle K C X—which angles indeed differ not perceptibly, as if they were at the center I. And since we have said above that the angles S E X and K C X differ not at all perceptibly from the angles C N E and E V C, if we shall know the quantity of the former, the quantity of the latter will also be known to us.

Since, then, the semidiameter of the elemental region is greater than the semidiameter of the Earth, as 33 to 1, and C N is reckoned as the said semidiameter (because it differs least perceptibly from it), now if the said N C be supposed to be the base of a right-angled Triangle, of 100000 parts, and we have said...

for if C N gives us C E as two parts when it amounts to 33 parts, what will the same C N, amounting to 100,000 parts, give us? From this, C E will come out as 6,060 parts, and its angle C N E will be $3^{\circ} 29'$. In the same way, there will also be the angle K C X, whose arc S X will be of the same number of degrees and minutes. I say the same of the arc X K. But around the said Star, all the others are not separated by an interval of this kind.

Diagram. A geometric construction supporting Benedetti's parallax argument [first figure]. At the bottom is a small circle (the Earth's globe) whose center is marked **I**, with the diameter endpoints lettered **C** (left) and **E** (right) and the point **A** marked above center **I** on the globe. Surrounding this small globe is a much larger circle. Above and outside the small globe, at the level where the rays converge, are the points **V** (left), **O** (center), and **N** (right) — the region of fire/exhalations. From the eyes at **C** and **E** (and from **A**), straight lines are drawn upward, diverging to the great arc at the top. Along that top arc, from left to right, are lettered the points **S**, **R**, the radiant **Star X** (drawn as a sunburst symbol), **T**, and **K** — points on the eighth orb. The lines **C N** and **E V** (and the diagonals **E O R**, **C O T** mentioned in the text) cross between the globe and the upper region.

- **I** (center of small globe): center of the Earth
- **C** (left end of globe diameter): one observer's eye / position
- **E** (right end of globe diameter): the other observer's eye / position
- **A** (on globe, above **I**): point on the Earth's surface
- **V**, **O**, **N** (above globe): the region of fire / exhalations (left, center, right)
- **S**, **R** (upper left arc): points on the eighth orb
- **X** (top center, sunburst): the New Star
- **T**, **K** (upper right arc): points on the eighth orb

[The text in the right-hand column of p. 739 belongs to Benedetti's continuing argument and is transcribed in sequence below.]

Nevertheless, neither you nor the other Peripatetics who have followed this opinion of exhalations — in order to preserve the nullity of the diversity of aspect [parallax] — affirm that exhalations can rise so far from the Earth. Indeed, you say they do not even reach the uppermost parts of the third region of the air, so that they do not enter their own fiery orb [igneus orbis]; and this orb, according to their opinion, begins not very far from the surface of the Earth, as I have already proved in my discussion against Antonio da Bergamo [Antonius Bergam.]. But let us grant that the said exhalations have risen through ten Earth-radii [Semid. Terrae], and let us then proceed as follows. Since **C N**, taken as 10, gives us **C E** as 2, what will **C N** itself give us when taken as 100,000? It will yield **C E** as 20,000, and the angle whose sine this is will be $11^{\circ} 32'$; and thus the angles **S E X** and **K C X** will be such, and accordingly their arcs **S X** and **K X**. But who would ever doubt that, within so great an interval, many other stars larger than the said Star are not present? I have drawn the lines **E O R** and **C O T** so that you might see the effect of the larger and diverse aspect.

of the diversity, from the eyes E and C, in the circle of altitude, when O would have been that most brilliant point of light and not X.

But someone may object to me that, since I O was longer than I E only by ten times, when the eye is at E or at C — at 90° from A — then the point V or N would not be seen by that eye, on account of the globular shape of the Earth.

Let us therefore imagine, from the point V, a straight line V B tangent to the quadrant A E at the point B, as may be seen in the second figure; and in it let there be drawn C B, I B, and I V, which I V will cut the arc C B at the point P into equal parts, and similarly C B at the point Y. There is no doubt about this, since C V is equal to V B by Euclid III.35; whence by Euclid I.8 the angle C I V will be equal to the angle V I B, and therefore the arc C P will be equal to the arc P B; and by Euclid I.4, C Y will be equal to Y B.

Diagram. The "second figure" of Benedetti's argument, an inset at the lower right of the page. At the top is the point V; from it two long straight lines descend toward a circle at the bottom. The circle has center I, with diameter endpoints C (lower left) and F (lower right). On the circle's upper right are marked A (above) and B (to the right, with a small tangent mark). Inside, the points P and Y are marked on the chords/arcs between C and B, near the center line I V. The line V B is drawn tangent at B; lines C B, I B, and I V are drawn.

- V (top): apex point, source of the tangent line
- I (center of circle): center of the Earth
- C (lower-left of circle): observer's position
- F (lower-right of circle): point on the globe opposite C
- A (upper circle): point on the Earth's surface
- B (right of circle): point of tangency of line V B
- P (on arc C B): point where I V cuts arc C B equally
- Y (on chord C B): point where I V cuts C B equally

Now, supposing C I to be a tenth part of C V, no one will doubt that, since V I subtends the right angle V C I (for we have already said above that the angle C differs insensibly from a right angle), C I itself, taken as the whole sine [sinus totus] P. 100,000, when its square is divided into 101 equal parts, one of those will be equal to the square of C I, while the remaining part will be equal to the square of C V itself, by the proportion doubled of the squares to that which their sides contain. But the square of V I itself is P. 10,000,000,000; therefore the square of C I will be 99,009,900, whose root C I will be 9,950 parts. Hence the square of C V itself will be P. 9,900,990,100, whose root C V will be P. 99,500. Hence the angle C I

V will be $84^{\circ} 17'$, and the angle C V I, which corresponds to the sine C I, will be $5^{\circ} 43'$; and its double — that is, the angle C V B — will be $11^{\circ} 26'$, nearly equal to the angle already mentioned above. But the sine C Y of the angle C I Y will likewise be 99,500 parts, of the kind in which C I is 100,000; but since C I is 9,950 parts, then C Y will be 9,900 parts — that is, almost a tenth part of C V itself. Therefore, if the eye at E will not see the point V, this point will be seen well from the eye at B, without any sensible diminution of the angle at the point V, as we have proved.

CORNELIVS FRANGIPANVS ITALVS [Cornelius Frangipanus, the Italian]

I have not had the chance to see this Frangipani's [Cornelio Frangipani] little book on this New Star, written in the Italian tongue and publicly published. But since the most distinguished man, Dr. Thaddaeus Hagecius [Tadeáš Hájek], makes mention of it in his *Dialexis* and briefly repeats and recounts the things put forward by him —

— whom there is likewise no doubt that he treats in good faith and candidly, on his behalf, since he is endowed with such integrity and sincerity of mind, and does not, as very many do nowadays, busy himself with detestable prejudice: distorting the opinions of those who disagree with them by quoting them corruptly and perversely and twisting them into another sense than the author intended, turning everything sooner to the worse than to the better part — or rather perverting it (that this was certainly not done by Thaddaeus, I would dare to pledge my faith, on account of the familiarity that exists between me and that man) — therefore the things cited by him concerning Frangipani's opinions we shall here briefly review, and discuss in a somewhat different way than he did.

Frangipani reports an opinion not very unlike Raimondo's [Annibale Raimondo]. For he too wished this New Star to be the same as the eleventh [of Cassiopeia], adding at least this to the former vanity: that it had moved away from its original place by two degrees toward the north, and that it had grown in brightness. But as for the fact that it changed its former and genuine place, he brought forward no observations or demonstrations by which to persuade anyone of a matter so absurd and incredible, thinking it enough to have stated it in this fashion. But who would ever believe, for his sake, that any of the fixed stars [Affixae Stellae] changed its place by one minute or another — let alone by two degrees — while the others remained permanently unmoved? For here there is no question of that very slow motion by which all the stars are carried with one accord about the poles of the ecliptic, by which in about 70 years they together complete one

degree (as we have observed); nor of that by which, from the changed obliquity, the latitude varies somewhat — both of which we have discussed at length in Chapter 2. These motions, he says, are naturally present in all the fixed stars, and by that established law; this Frangipani did not consider. Rather, he supposed that the eleventh star had migrated by a violent kind of motion, and contrary to the customary principles, toward the north — toward the septentrional [region] — by two degrees, and had at the same time increased its light. In this respect, he has not only embraced Raimondo's ineptitude — that the stars can be made larger and their light remarkably increased (although by a different reasoning than Raimondo wished) — but he has also heaped error upon error, attributing to this star of Cassiopeia a peculiar and extraordinary motion beyond all experience. For in no age, from the first observation of astronomers — which has continued for very nearly two thousand years and been committed to writing — has it ever been recorded that any of those stars which are in the firmament beyond the circuits of the planets has altered its own place, without the accompaniment of the rest. For all of them have perpetually retained the same arrangement and distance with respect to one another, nor have they suffered any alteration in light or in magnitude. So that this might be known more certainly, Hipparchus [Hipparchus], that most ancient astronomer, undertook with immense labor to mark down the positions of all of them that are visible to sight, by means of fixed instruments, and to determine their magnitudes and configurations — as may be gathered from the words of Pliny cited in the third chapter of this book, who proclaims him by this title wonderfully and magnificently. Indeed, this same Hipparchus,

— in order that posterity might be more certain, marked down the fixed stars, their mutual constitutions and predefined places, so that they should not be confused or in any way vary; and he noted that certain stars had been placed in his own age in one and the same straight and linear track. Ptolemy [Ptolemaeus], 265 years afterward, found these same stars to hold exactly the same arrangement, and observed many others besides, which were disposed in a direct line of position with respect to one another. That all these behave in the same way in our own age, together with the Hipparchian [stars] — more than two thousand years [Margin: t fere] having elapsed from Hipparchus's time — I myself have experienced, as I have recounted more fully in Chapter 2, in order to refute the utterly false opinion of those who have imagined that the fixed stars [Stellae Fixae] can suffer some anomaly with respect to one another and a divergence from their former arrangement, contrary to all truth and experience.

I do not indeed deny that the fixed stars [Stellae Inerrantes] do not now display exactly the same places in the heavens, as regards longitude and latitude, and hence the distances deduced from them — with respect to the eighth sphere [Octava Sphaera] itself, and taking the change of the equinoxes into consideration — as the Ptolemaic *Abacus*, derived from Hipparchus onward, requires. But this disagreement must be imputed not to the stars, nor to the heaven itself, but to the observations of the craftsmen, less accurately performed of old; or else, on account of so many transcriptions made over so long a time, in which an error could from time to time creep in through carelessness — or it happened from both causes. The discrepancy that occurs in these matters will easily come to light from a comparison of our restitution, drawn from sound observations, which we set forth in Chapter 2, applied to the denotation of the ancients.

Since, then, nothing of this kind has happened to any one of all the fixed stars through so many ages, with what rashness, I ask, did Frangipani dare to ascribe to that eleventh star of Cassiopeia a thing so unusual, which no experience and no observation, nor any just proof, has established? Indeed, that eleventh star, while the New Star still endured, was seen to remain in the very same place which it had held since the founding of the world, just as it had before, as we have shown.

He had the occasion for so gross a hallucination, without doubt, from this: that, when he had observed that the New Star — which he supposed to be the eleventh — had a latitude from the ecliptic greater by about two degrees (for since a third part of one degree was lacking, it was too much for him to discern) than is assigned to that eleventh star in the tables (although there it is in fact larger than the just value by nearly half a degree, so that there was no need on that account, owing to the numbers of the tables, to make that star two degrees more northerly so that it might agree with the New Star's place — but only one degree and a quarter was available for weaving and covering over this error). And since that eleventh star, on account of the brightness of the new light, was at first not very conspicuous in that vicinity, he supposed that it had been absorbed into this New Star, and had changed both its place and its magnitude — just as Raimondo too was deceived from the very beginning in this matter, so that he could not discern that eleventh star which was near the New Star, nor any [other]

that a star was present in that vicinity. He is therefore quite wrong: that eleventh star of Cassiopeia did not change its place, nor was it identical with the New Star, since both were seen together in the heavens at the same time, each in its own

location. Frangipani's supposition [Cornelius Frangipani] is therefore entirely false.

He was no less deluded when he supposed that the light of this little star had been augmented in the manner of the Moon's illumination. For what does this illumination have in common with the Moon's monthly waxing and waning, which depends on how much of the part lit by the Sun is turned toward us? Who among astronomers and natural philosophers does not know that the Moon shines with no light of its own — or with an extremely faint one — but only reflects toward us, and borrows solely from the Sun, the light it has? Some, to be sure, fancifully imagine that one half of the Moon has its own light while the other is dark, and that the Moon so turns itself in sequence, with respect to the Sun and to us, about its own center, that it might plausibly be thought to draw its light from the Sun. But this notion — I say — is plainly a fiction, and if nothing else, the lunar eclipses, when the Moon is deprived of its light by the interposition of the Earth, clearly prove it. For if the Moon enjoyed a light of its own, it would surely not lose that light when it lay in the Earth's shadow, but would display it all the more plainly. Every light shines more in the dark, so long as it is not overpowered by some other, greater brilliance. Nor is the Earth's shadow any corporeal thing or dense substance that could darken the Moon's light or snatch it from our sight; rather, it is merely a certain deprivation of the Sun's light, owing to the interposed opaque body of the Earth. But this is not the place to treat these matters at greater length.

The stars, then, are not illuminated by the Sun in the way the Moon is. For they are not bodies opaque in themselves; rather, they either possess a light of their own, divinely implanted in them from the beginning, or, if they do receive some brilliance from the Sun, they take it up over their whole body and preserve it equally throughout all their parts. This latter view, approved by many — ancients as well as moderns — is supported by many weighty arguments, which there is no need to rehearse here. And even if it be granted to Frangipani that a star is illuminated by the Sun in the manner of the Moon (which is in fact false in itself), why does the same not happen with other stars, so that they too should sometimes increase and diminish their light? And why did this eleventh star, when the Sun returned to the same disposition relative to it that it held when the star was thought to be so bright, not likewise acquire the same abundance of light, as happens with the Moon, and duly display the intermediate phases of increase and decrease?

He also calls in, as testimony and confirmation of his absurd assumption, what Ovid reports about the seventh star of the Pleiades (which they call Electra), hidden away at the fall of Troy. He further adduces — but with no authority and no observational evidence — that the Pole Star vanished from sight after Constantinople was stormed and conquered, and that from that time on we have been deprived of its appearance.

Both these claims are mere fabrications: the one invented by Frangipani himself, or by some other equally trifling author; the other taken from the poets, who sought to express the wretchedness of Troy's fall more pathetically — since Dardanus, the founder of the Trojan city, was thought to have been born of his mother Electra (though some give the name Merope to this little star of the Pleiades, the one that shines less than the rest). But let me set down the verses of Ovid, out of which Frangipani built his own conceit, constructing one falsehood upon another.

The Pleiades begin to lift their father's shoulders, They are called seven,
yet they are wont to be but six: Whether because six of them came hither
into the embraces of the gods — For they say that Asterope lay with
Mars; Alcyone to Neptune, and you, fair Celaeno, And Maia and Electra,
and Taygete to Jove. The seventh, Merope, married a mortal, Sisyphus, to
your sorrow: She repents, and alone hides for shame at the deed. Or
because Electra could not bear to look upon Troy's ruin, She did not
endure it, but set her hand before her eyes.

But if from these and similar fabulous inventions of the poets it is permissible to establish some certainty, whether astronomical or physical, then surely it must be drawn out in another way — not from the outward form of the words, but from the inner sense that the poets and the older philosophers concealed beneath such wrappings. Otherwise, how many gods and goddesses, and what trifling tales, shall we mix into heaven, earth, and sea? Since, then, Frangipani tries to prove his own fable about the New Star out of the poets' fables, he fashions one falsehood that is just as false as the one he started from, and so betrays the vanity rather than the truth of his assertion. Nor does he sufficiently bear in mind, while he too licentiously abuses the poets' license in composing fables, that painters and poets have always had equal liberty to invent boldly — but not astronomers and mathematicians.

If we have been deprived of the Pole Star ever since Constantinople was captured by the Turks, then what will that star be which is seen in the tail of the Lesser Bear at a distance of nearly three degrees from the pole — the one which

everyone up to now has called the Pole Star, on the grounds that it is the nearest to the arctic pole itself (apart from a certain tiny star of the fifth magnitude, so faint that it does not strike the eye)? Who has ever seen any other star near the pole that has now vanished? Surely all those stars that were catalogued by Hipparchus and Ptolemy are still visible there to this day, and nothing of their number, magnitude, or even shape has been lost. Indeed, more stars than the ancients recorded are visible there, just as over the whole face of heaven; though the ancients passed these over because of their extreme smallness, and because they could not be enclosed within definite figures.

But let these dreams and fabrications of Frangipani prevail — unworthy as they are of being repeated or refuted at greater length.

The miraculous eclipse of the Sun that occurred at the Passion of the Lord has nothing to do with the case (as he would have it). For that eclipse was displayed by God beyond the whole order of nature, so that He through whom all things were made might bear witness that He suffered as a man — as if in compassion and turning away His face. Nor has any such thing ever been seen at any other time since the creation of the world, just as that miracle of the Incarnation and Passion of the Son of God far surpasses, in all of nature taken together, every other miracle that could ever exist. And as for his bringing in here the eclipse at the battle of Agathocles against the Carthaginians, that has nothing to do with the matter. That one, if it occurred at all, was natural. Why then does he not summon the other solar eclipses to his aid? Will it serve his purpose that, by the Sun being wholly or partly withdrawn from our eyes through the interposition of the Moon, the appearances of some New Star, risen from heaven and then completed, should be saved?

It might seem plausible — what he adds besides — that stars have sometimes been seen by day, and shining brighter and more brilliant than usual, if this too did not have its just and natural causes. For it happens with the planets that they sometimes appear larger, when in their orbits they are brought nearer the Earth — that is (as the common account of their motion has it according to their model [hypotyposis]), when they are near perigee, both on the eccentric and on the epicycle. So with Mars: because of the great size of its epicycle, this is more characteristic of it than of the others. In the year 1593, around the months of August and September, when it stood opposite the Sun not far from the perigee of its eccentric, it blazed with a greater quantity and brightness of light, so much so that to many ignorant of this cause it could be taken for some new star.

Thaddaeus [Thaddaeus Hagecius] recalls that the same thing happened earlier

too, in the year 529, and that it was foretold by Andreas Perlachius [Andreas Perlach], professor of astronomy at Vienna. Moreover, this same Mars, every other year, when it becomes acronycal [acronychus], appears larger than usual; and every twenty-fourth year it is increased still more, by reason of the eccentricity, when at that time it is brought nearer. So Venus likewise, from almost the same causes, is very often seen larger than at other times — so much so that occasionally it can be seen by day together with the Sun. This is something peculiar to it beyond all the other planets (the Moon alone excepted). Hence we have built up here a foundation for restoring the places of the fixed stars that is by no means weak or unstable — as the second chapter of this book plainly attests.

Therefore, since it comes about by necessary reason that the planets are sometimes seen larger and sometimes smaller, and that the star of Venus is sometimes seen by day, Frangipani alleges these things in vain to bolster his frivolous opinion — especially since this happens not with the fixed stars, about which the question chiefly turns here, but only with the planets, and not even with all of them equally.

The remaining things which Thaddaeus records that Frangipani brought forward — foolish, empty, and not free of impiety in their abhorrent prophecies and judgments, urged with grave prejudice and an unruly passion of mind, and without any just grounds — I am unwilling to touch on here even with a single word. We have judged it better, partly because we prefer to abstain from examining such predictions and soothsayings, and partly because these trifles of Frangipani are in themselves so slight and futile that to recall and weigh them would be nothing other than to undertake sterile and fruitless labor — or, as the proverb has it, to scatter perfume on a dunghill. So I shall add no more on this matter, since perhaps these very things have already been dwelt on more than they deserve.

On Bartholomeus Reisacher, who before he discerned everything more correctly held the same opinion as the aforementioned Italians regarding the illumination of the eleventh star of Cassiopeia: and concerning another, an Anonymous German, who imagined something similar about another star, which is the twelfth in number.

Such is the nature of human beings that, just as nothing is said so aptly and truly that it does not find its detractors, so too nothing is asserted so absurdly and incompetently that it does not find its supporters and champions. For what could be said about this wondrous star more foolishly and more remote from all certainty than the things which, in the preceding pages, we mentioned were put forward by the two authors there indicated? And yet these claims, inept and ill-conceived beyond measure as they are, won supporters not only among the Italians but among the Germans as well. Indeed, among these was that otherwise distinguished mathematician Bartholomeus Reisacher [Bartholomäus Reisacher], professor of these disciplines at the University of Vienna, long and widely renowned for their cultivation. He was at first of almost the same opinion as Hannibal Raimundus [Hannibal Raymond] — namely, that the eleventh star of Cassiopeia had been illuminated with a greater light through the interposition of some other transparent body. And this he held before he could, because of the New Star's brightness, distinguish the eleventh star adjacent to it; but afterward, once the matter had been better examined, he retracted the error and corrected himself. So that this may be the more readily understood, I shall add Reisacher's very words, drawn from his own writing on this New Star.

Another opinion is that of those who indeed place this appearance even in the elementary region: but they think that, on account of some vapor interposed between a certain star and our sight, scattering the visual rays and representing that star under a greater size, the star itself is the cause. Of this opinion I too was at the beginning. For on examining its appearance...

once I had been made more certain — first by setting up the celestial Globe and examining the star's position on it, then by comparing it against the sky using that delineation of the constellations which shows how each is figured on the Globe, and again on certain planar diagrams drawn up by skilled craftsmen, most especially by Alessandro Piccolomini [Alessandro Piccolomini], a mathematician

of no small note, in that well-known compendium of his for learning the Fixed Stars, where the constellations are depicted without any outline drawn around the figures. That well-known quadrilateral [tetragonus], made up of those four stars — the second, fourth, eleventh, and twelfth of the figure of Cassiopeia [Cassiopea] — seemed to me to represent entirely that celestial quadrilateral. I used to suppose, however, that the star in question was the brightest of those, the one numbered eleventh and of the fourth magnitude, which is placed by Ptolemy, Copernicus, and other astronomers at the foot of the seat, that is, at the base of the throne of Cassiopeia. (For I could not at the time make out separately that little eleventh star, both because of the weakness of my eyesight and perhaps because of the brilliance of that bright star, whose light, being less obscuring, outshone it; yet the other stars of the fourth magnitude appeared to me clearly enough.) I judged it the larger because of the intervening transparent medium — a vapor, as it were (as Aristotle [Aristotle] puts it), or some sort of condensation denser than the air itself, yet, by my own imagining, transparent like glass or crystal, interposed between our sight and the aforementioned star, and dispersing the rays of vision. As for the fact that the star kept watch upon and followed [the pole], much as a magnet does the Lesser Bear, or the arctic Pole, and finally just as chicory and the heliotrope, plants known to everyone, look to the Sun alone and follow it — I confirmed this opinion of mine in part also by the authority of Aristotle in *Meteorology* I (*Meteorologica* I), where he says: when, therefore, such a condensation has occurred next to a star, it necessarily follows that it appears at the same place and that a comet is moved, which is said to be a star.

Whether that condensation had been kindled into flame I was at first indeed in doubt. But once I had examined and grasped Aristotle's view more carefully, it seemed reasonable that it could be said and held to be a comet — but a comet of the kind Aristotle describes at the cited passage, namely one caused by a condensation or exhalation underlying some aforementioned star, and that this was the cause of the appearance. Yet when at last I came to understand, from others endowed with keener sight, that that small star appeared separately on its own — and indeed since that star, now reduced in size and brightness, could be easily distinguished by sight from the other; and since at that very same spot no other separate star is placed by astronomers, and consequently no transparency of the kind I had imagined could produce any magnifying effect on the sight — I had no doubt that the star itself was a different and foreign one, brought about by the arguments to be set out hereafter.

The arguments he discusses here were drawn not so much from the immobility of its place, from its non-scintillation, and from its form, as chiefly from the imperceptibility of its parallax [parallaxis] — as was pointed out in Chapter 8 (*Cap. 8*), when we examined Reisacher's [Bartholomäus Reisacher] own treatise. There is therefore no need to rehearse them again here.

Since, then, Reisacher himself corrects and retracts his first conceptions — which did not match the actual appearance of the New Star [New Star of 1572] — and afterwards acknowledges and professes the truth, once it had been more rightly disclosed, I do not think it necessary for us to discuss this at greater length, especially since the ineptitude of that assertion is sufficiently plain from what has been said above. This much at least I will say: the very medium by which the star was supposed to become larger and more brilliant was, on his account, something the star itself followed and constantly looked to, by a kind of magnetic principle — and just as a certain plant accompanies the Sun's daily motion by the inclination of its flowers,

so too [he holds] the star does, relying on Aristotle's authority for this, since Aristotle held that comets are sometimes formed and have their motion obscured beneath certain fixed stars. Although what Reisacher brings forward may seem plausible enough, it cannot be properly established as consistent with Aristotle's view, which is not even self-consistent. For if some comet could be generated below a given star in the Elementary Region, then surely with its own head and rather dense body (I do not now speak of the rays issuing from the body, like a tail) it would cover that star, and, if it were directly interposed, would withdraw it from our sight and by no means render it brighter. Nor can such a magnetic power properly be attributed to dry exhalations — that for several months they should look unceasingly upon a definite star without any deviation. Add to this that throughout its whole revolution, with respect to our sight, it would not remain directly on that line which runs toward the star, because of the disparity introduced by the parallax arising from the Earth's semidiameter. For if it appeared so to some observers under a single horizon, it certainly would not for others, owing to the curvature of the Earth. Indeed, even if this accompanying were referred to the Center of the Universe, that is, to the Earth, it still would not agree in one and the same horizon, with respect to a higher elevation of the star as against a lower one, in the same manner. So it must necessarily follow either that those exhalations occupy so vast a space as could suffice for this whole wandering that the parallax happens to involve — which would indeed swell to as great a magnitude as any comet ever seen, or as can be attributed to persisting exhalations, so that not one but several stars in the vicinity would likewise be

covered; or that one and the same body can be in different places at once, which is repugnant to the axioms of natural philosophy; or else (and this is by far the truer view) that no such medium is everywhere and always interposed before the star — and therefore that what is assumed is false. Just how this follows from what has been said becomes fully clear when we were discussing Raimundus's [Raimundus Frangipani] fancies. By this argument too it is quite plain enough how inept and unskilled Aristotle himself was on this point, since the very geometrical demonstrations drawn from the property of parallax cry out altogether against it here.

I have set out Reisacher's statements all the more willingly so that it might be the better seen on what occasion those two Italians, whom I treated in the preceding pages, also went astray — since to them too, before the New Star remitted from its original brilliance, it appeared the same way, just as we ourselves above traced out and pointed to the occasion of their error. But whether, like Reisacher, they later learned better, came to a sounder view, and corrected their mistakes; or whether they persisted in them — whether deliberately, so as not to be charged with having blundered so grossly, or out of ignorance — since this is uncertain to me, I leave it in doubt.

ANONYMVS ILLE GERMANVS.

[That Anonymous German]

In the same way a certain German too — whom Doctor Thaddaeus [Thaddaeus Hagecius] recalls in his revised *Dialexis* — captivated by a similar sort of imagining, ventured to put forward almost the same thing, not, however, about the eleventh, but rather about the twelfth star of Cassiopeia.

Since that author's treatise has not come into our hands, and since I am not even certain of his name (for Thaddaeus, sparing him, suppressed it), yet so that it may be plain how easily even men whom we suppose to excel in some branch of learning may slip into error, I shall set down Thaddaeus's own words about this same Anonymous — words which (as I said) he afterwards inserted into his *Dialexis*, and which run as follows:

There was another, also a German, who followed nearly the same opinion as Raimundus and Frangipani, differing only in this: that he supposed this New Star to be in the middle of the ascent of the Throne and the twelfth in number, whereas they contended that it was the eleventh in number. For this opinion of his he had no reason other than this one: namely, that that bright star alone, the twelfth in

number, with no others among Ptolemy's Phenomena, seemed to him to represent a rhomboidal figure together with the 13th, 2nd, and 4th. There could therefore be no other than the 12th. But this opinion too is so false, and betrays an ignorance of the heavens and the stars so shameful, that it is thought worthy of no refutation.

Thaddaeus judges rightly that this assertion displays so stupid an ignorance that it scarcely deserves any rebuttal. For it is entirely false that the thirteenth, second, and fourth of Cassiopeia, together with the eleventh, make up a rhomboidal figure — except in a very forced way; nor can the same be proved from Ptolemy's Phenomena. On the contrary, that eleventh star, which is a little larger than the thirteenth, more correctly forms a rhombus with the twelfth and the remaining two. And who ever brought forward the thirteenth — which is at the very top of the seat and scarcely appears as of the fifth magnitude — to be enlisted here? I therefore suppose that that German chose to seize upon this twelfth star as the New Star rather than that eleventh one so celebrated by the Italians, because it is larger and more conspicuous than the other; and so there would be no need to hunt up, with such great effort, occasions for its illumination — since that which is of itself brighter takes on a greater illumination more readily than what is endowed with duller and lesser light. Meanwhile he failed to notice that by this reasoning he had displaced the New Star's location from its true position, which the heavens themselves showed, by more than five degrees [*ultra quinos Gradus*]; and that he had imputed to both that star and the twelfth what could least belong to it. But since this speculation has no plausible pretext by which to put a false color upon the truth, and betrays only sheer ignorance, I am unwilling to waste good hours uselessly in refuting it.

But, leaving aside those who reported that the star we are treating of was not new, but a certain old star of Cassiopeia — whether this one or that one — endowed with a brighter light through the interposition of some intervening body (the falsity of which opinion, if nothing else, this at least plainly proves: that at the very spot where the New Star stood, no trace whatever of any star, not even the least, remained after its disappearance) — we shall now proceed to those who held this star to have been a comet, and who, begrudging it the heavens, assigned it to the sublunar regions.

D. ANDREAS NOLTHIVS EMBECCENSIS.

[Doctor Andreas Nolthius of Einbeck]

Passing over, then, the smoky and truth-obscuring speculations of those who supposed that some star, an old one, had blazed up through the intervention of

dry exhalations to so great a magnitude and brightness as this New Star, surpassing all the rest — let us now turn our discourse to those who, judging this star to be recent both in body and in position and in light, and wholly elementary in its substance, thought, rather than knew, that it had come to be in the sublunar Air, and who, believing it not unlike the customary appearance of comets, indeed believed it to have been formed below the Moon, and publicly put forward this view. Among all these the first to confront us is the distinguished man, otherwise a Mathematician, Andreas Nolthius [Andreas Nolthius] of Einbeck, who dared to publish opinions about this star so far removed from the truth, and even to offer and dedicate them to the most illustrious Prince, the Landgrave [Landgrave of Hesse], a man of excellent knowledge in these matters.

Now it might be granted that he had some understanding of Regiomontanus's [Regiomontanus] *Problems on the Measurement of Comets* (which he himself also mentions in his Latin Preface, addressed to the said Prince), and that this is in itself ingenious and praiseworthy. Yet from this he gains nothing toward having it believed that he pronounced anything in keeping with the nature and location of this star, so as to call into question and set aside what others observed, differing from his own findings — he presumes too boldly.

But since he brought this matter before a Prince exceptionally versed in astronomical affairs, and, through long practice in celestial Observations, thoroughly expert, he is refuted — quite abundantly, by the very Observations of that most illustrious Prince, noted around the beginning of Chapter 8 (*Cap. 8*) — of having gone astray with respect to the whole heaven; just as is plainly clear from those things which we appended there for the unraveling of the parallaxes.

But so that this Nolthius's tenets may be examined more deeply and weighed in a just balance, we shall submit to scrutiny — in the very order in which the several points follow one another — what he asserts in that same treatise, published in the German tongue and comprising eight Chapters.

In Chapter One [Capite Primo], on what comets are — (for he does not [hold] this star above measure...)

labors to explain it away [the New Star] as something to be wondered at only "until" it can be reckoned among the ordinary comets of the common sort, and to expose it as such to the unlearned. But, deceived by the authority of the Peripatetics, he ignorantly leads both himself and others astray in this matter, off the path of truth. For while he binds himself to the Aristotelians in these pronouncements, far too confidently and slavishly, he follows blindly — taking,

in this matter, an inexperienced guide, and going blind together with him. By what unconquerable demonstrations [Apodixibus], and from what sure geometrical observations established by proof, did Aristotle ever show that comets must necessarily be generated below the Moon? And since this is altogether false — as the following books, which deal with several comets of our own age, will make plainly evident without any hesitation — that dry, fatty, and viscous material which he assigns to them is certainly a fiction, devised to be at most merely plausible.

In vain, therefore, does Nolthius try to ground mathematical certainty — which is far more evident, and not subject to any just objection — upon the uncertain and arbitrary conjectures of the natural philosophers, when on the contrary it is Physics that ought to be assessed from Mathematics, and tested as to whether or not it agrees with the truth. Yet since for so many ages now nearly all who profess philosophy have been steeped in this false opinion about comets through Aristotle and the schools, it will not be altogether surprising that Nolthius, however much a mathematician, is no more clear-sighted than the rest — when even Ptolemy [Ptolemaeus], the prince of astronomers, seems in this matter partly blinded by that same Aristotle. As for Pliny [Plinius] (whom Nolthius also cites in his own support), it cannot be asserted with certainty that he assented to Aristotle's opinion concerning the position and generation of comets — since Pliny in fact reckons comets chiefly among the celestial bodies, and touches on Aristotle's conjectures about them only in the last place, and as it were in passing, in the very fewest words.

But indeed, since in the following books we demonstrate — with geometrical and unconquerable certainty — that the five comets (which we have hitherto been continuously occupied in observing accurately) necessarily ran their course far above the Moon, within the enclosures of the ethereal world; and since we then also examine the various opinions raised here and there by others, among them this Aristotelian one which has prevailed above the rest and taken root; and, testing them against the touchstone [lydium lapidem, "Lydian stone"] of truth, refute them, and substitute whatever can be established as more consonant with the truth concerning these matters — I do not think it worth the effort to dwell on these things at greater length here. It is enough to have plainly shown this opinion of Nolthius, concerning the essence and generation of comets, to be erroneous — drawn, as it is, at best from Aristotle's speculative [stochasticis] dogmas, and without sound reasons; and that he has attributed to this strange, miraculous star — which has almost nothing in common with the comets themselves — all the experience that belongs to ordinary comets, which appear

more frequently, so far is it from applying here. But let this suffice concerning the first chapter.

What he brings forward in the **second chapter** — namely, of which species of comet this phenomenon should be reckoned — collapses likewise, since it rests upon a foundation equally weak as the previous ones. For even if two kinds of comets are posited by Aristotle...

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by Aristotle [Aristotele] — one the "hairy" comet [Crinitum], which casts its mane on every side, and the other the "bearded" comet [Barbatum], which extends it toward one side at least, keeping it the same; which is indeed, for the most part, how the matter rightly presents itself in appearance — yet neither of these two represented the star in question. For it put forth no streaming hair, nor did it bristle round about, but glittered with a radiant brilliance like a genuine star, unless one chose, improperly and falsely, to call "hair" those rays which it shot out all around — in which case the Sun [Syrium, recte: Sirius] and the Lyre [Lynam], the Goat-star [Capramque, Capella], and other brighter stars that shine with their own light, would have to be said to be "hairy," whoever might pretend it. For this New Star differed in no way at all from those stars; rather, it surpassed them somewhat in untainted purity and splendor of light.

Without just correspondence, therefore, does Nolthius liken this star to those comets which Aristotle calls "hairy," and which scatter their mane in all directions — since it displayed no trace of a comet, whether streaming or rounded, but shone for us in no other way than a genuine star of the firmament. I do not indeed deny that there are comets without a beard, the prominence projecting in one direction — whether this happens accidentally, because they are situated opposite the Sun and turn their longer tails away toward the upper regions, out of our sight; or whether they really lack the longer tail, or have one so faint that it cannot be seen. For a comet of just this sort was carefully observed by us in the year 1585, which throughout the whole duration of its course showed no perceptible sign of a tail, but appeared only somewhat rarer, as if filled with certain fibers, near its circumference, and shone less brightly there; whereas in its very middle it was seen more compact and brighter. Nevertheless, under this species of comet this Star is by no means to be comprehended. For not rarely, with a faint and dim light, did it fashion hairs here and there about its outermost edge, in the manner of such comets — rather, it blazed with a bright and pure light over its whole body; nor were the rays it emitted blunt and dim, but conspicuous with sparkling clarity. So that not even Aristotle himself, had he

lived, would rightly have attempted to reckon it among any species whatever of comets.

He also cites in his own support Epigenes, who — on Seneca's [Senecae] report — likewise established two kinds of comets: one tailed and endowed with motion, the other emitting flame on all sides and lacking motion; and under this latter kind he includes the modern star [Stellam Neotericam], on the grounds that it too was immobile. But this opinion of Epigenes agrees only with the rarest experience — however much Pliny may hint at something similar. For of all the comets that are recorded by historians, few are wholly without a tail, and fewer still among these are found to be perpetually stationary in one place. Certainly the one we mentioned earlier, which in the year 1585 was watched for a whole month — though it was round and lacked a tail — nevertheless displayed a quite perceptible proper motion, by which it was carried from west to east, so that...

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from the beginning it covered more than two degrees daily, and afterward gradually and steadily slackened the same. But grant that comets are sometimes shown to be round and immobile. Is this Star on that account to be equated with them — when it was allotted many other properties differing from theirs: such as clarity of light, scintillation similar to its own in every part, longer duration, and certain other things reviewed in chapter 3 [Cap. 3], and besides inculcated here and there throughout the third part of this book — properties peculiar to itself?

It appears that this Epigenes (as is clear from Seneca, who reported these things about him) corrupted the opinion of the ancient Chaldeans concerning comets — contrary to what Apollonius of Myndus [Apollonius Mindius], his fellow-disciple, did, a man whom Seneca calls most expert in the investigation of natural things, and who drew from the same sources. For he reported that the Chaldeans place comets in the number of the wandering stars [Stellarum Errantium, the planets] and hold their courses to be regular. And if this is rightly understood — namely, as concerning certain adopted and new wanderers, not lasting long, whose course too is proportional and ordinary — then nothing absurd at all has been pronounced by the Chaldeans in this respect. For just as the following books, treating expressly of several comets, will make manifest, those comets move in the celestial world after the manner of planets, not with a disorderly and irregular motion, but exercising a course ordered and mutually proportional (to which, moreover, a fitting hypothesis can be adapted to account for it).

Why, then, did Nolthius not rather follow the opinion of Apollonius, drawn from the tenets of the Chaldeans — which was more in agreement with the truth — than the erroneous opinion of Epigenes? Especially since Seneca himself, from whom he cites these things, declared outright that comets really exist in the ethereal world, contrary to Aristotle and those who think otherwise. So it usually happens, for the most part, that from the authors cited, only those things are culled which flatter each person's own preconception, while the rest, which run contrary, are passed over — though these would point more rightly to the truth.

It is moreover frivolous that Nolthius supposes, in the same place, that the New Star did not keep exactly the same distance from neighboring Cassiopeia [Cassiopeae] perpetually, but wavered somewhat one way and another; and he reckons that this should be ascribed rather to its parallax [Parallaxi] than to the influence and agitation of the planets ruling over it — when in fact each of the two is, beyond all doubt, inconsistent. For it neither felt the influence of any planet, nor was it shaken by this; nor did it yield even in the least perceptible degree to parallax — as we have abundantly demonstrated from accurate observations in the second part of this book.

In the **third chapter** he labors — with a fruitless effort — to investigate the astrological causes that produced this Star (which he always falsely calls a "comet"), and thinks he has found three of them, brought forth with much sweat and fetched from far too far afield: one, an opposition of Saturn [♄] and Mars [♂] in Taurus [♉] and Libra [♎], which occurred in the year 1572, in the month of March; a second, an eclipse of the Moon exhibited on the 25th day of June of the same year, in the middle of Capricorn [♐]; a third, a conjunction of Saturn [♄] and Venus [♀] in Scorpio [♏], celebrated in the following August. To these three causes he adds certain particulars...

[p. 754]

that he may make the matter more plausible. But if, on so slight an occasion, and from causes that so often recur — indeed from far stronger ones than these — new heavenly bodies or comets could come forth, it ought rather to be a wonder that such things do not shine out every year, than that they are seen somewhat rarely. For what do lunar eclipses, however great (let alone one so small as the one he is speaking of), or an opposition of Jupiter [♃] or of Mars [♂], or a conjunction of Mars [♂] and Saturn [♄], contribute to this — when such syzygies [Syzygiae] occur frequently, and in themselves carry no great weight among the astrologers — especially as regards an effect so rare and so full of wonder, to be derived from this source?

Yet, that he may persuade us these were the true and natural causes of this unusual portent, he throws dust in our eyes: namely, that the place of the Star, according to its longitude, fell within the Zodiac between the rays of the conjunction of Jupiter [♃] and the opposite of the conjunction of Saturn [♄] and Mars [♂], and was as it were besieged and hemmed in by these. O fine proof! As if the rays of these planets — darted from places other than where they were when the Star existed — had the power to form and constrain this Star! If it is permitted to fashion causes in this way, from what is no cause, what in the end shall we not confidently affirm? And if this Star was the offspring of any of the planets, or procreated from their influence, why did it remain unmoved? Why did it not at least to some degree imitate the motion of those that beset it? And why do they not more often bring forth offspring of this kind? Can the star of Mars, in the configurations of the other planets, obtain greater prerogatives, or, entering the Sign of a lunar eclipse, be able to form new stars or comets? Did the ruddier color of the Star, which it took on about three months after its first rising, come to be imputed to Mars? And why did it not rather draw its tincture from Jupiter and Venus, since, like them, it shone for a long time from the beginning with a clear and whitish gleam?

But just as the body and essence of this Star did not draw its origin from the planets, so neither did its color, nor its other accidental qualities. Let those things, then, which Nolthius here summons from the fictions of the astrologers, have their leave — unworthy that they should be refuted at greater length, or anxiously dissolved.

Let us rather inspect the **fourth chapter**, indicating what kind of astronomical observations of this heavenly body the author here attempts to deduce from the sky, and what he tries to infer from them — since the inquiry into truth in this business must be grasped from the observations themselves and the demonstrations deduced from them. When, therefore, he comes to the observations, he brings forward certain ones for a single day — namely the 29th of November — in a very loose and careless manner, and not even by means suited to so great a task, marked as much by their loftiness as by their refinement, free of all error. Yet whatever they may be, we shall now weigh them.

He says that on the aforesaid day he observed this Star (which to him is a comet) in horizontal azimuth, from the equinoctial rising toward the north, the number reckoned at p. 60./0; and that it then had a measured altitude of p. 77./0, so that it was distant from the zenith by exactly 15 parts [Partibus]; and that, in order to determine the moment of time, he detected the altitude of the bright star of the

Lyra [Lucidae Lyrae, Vega] at the same instant to be p. 41/35. Assuming, moreover, the longitude...

the longitude of Lyra at $8^{\circ}29'$ Sagittarius [$\times$], with a latitude of $62^{\circ}0'$, just as the Copernican reckoning supplies it for that year. From this he derives its right ascension, computing $275^{\circ}5'$, and its declination, $38^{\circ}41'$. Then, by a triangular computation, he establishes from these the right ascension of the mid-heaven at the time of this first observation as $344^{\circ}6'$.

He next carried out a second observation, when the star was thought to be on his meridian, finding at that moment an altitude of Lyra of $33^{\circ}51'$. From this he again found the right ascension of the mid-heaven, which he reckoned in common with the star at $357^{\circ}11'$. Subtracting from this the earlier right ascension, he obtained the arc of the equator that had elapsed between the two observations as $13^{\circ}5'$. In this way the interval of time between the two observations worked out to $52\frac{1}{3}$ minutes [m. $52\frac{1}{3}$] of a single hour.

With these data, and taking the elevation of the pole at Embeck [Einbeck] as $51^{\circ}42'$ (the value he reports having previously observed for it), he derived, by the science of spherical triangles, the true declination as $61^{\circ}49'$, and the true distance from the zenith in the circle of altitude, at the time of the first observation, as $12^{\circ}21'$. And since, by observation, he had found the apparent altitude to be precisely 13° — which, subtracted from the true altitude, yields the parallax in the circle of altitude common to both — he concludes by measuring the difference, namely that the parallax at that same first observation was $0^{\circ}39'$. He commends this parallax for its usefulness and necessity, on the ground that without it the distance and magnitude of the star could not be obtained — and, indeed, this point would correspond to the truth, were it not in fact contrary to the matter as he has defined it.

Therefore, when I saw that Nolthius attributed so enormous and monstrous a parallax to this star, and that at so great an altitude as well — to no purpose — although I was not unaware that his very observations were by no means reliable, nor adequate to the task, I nonetheless made the attempt to see whether some flaw might also lie hidden in the calculation itself, especially since he, as he ought to have done, had set out the procedure of the demonstration but had not applied it to the numbers he had found. And in case some difference of any importance had crept into the computation he carried out — one I had not detected — I wished nonetheless to fit our own demonstrations and calculation to the Nolthian data, so that what he wished to say might emerge more clearly and as derived from geometrical sources, and so that at the same time it might be

established — as I just said — that, in the numbers themselves here, Nolthius had not gone astray.

Assuming, then, the same position of Lyra that he cites (however poorly it accords with the celestial situation of this star), and likewise the same right ascension of it, together with the declination which he duly applied to the assumed longitude and latitude, we will hunt down — by this rule — the arc of the equator passing between the two observations, that is, across the mid-heaven.

In the figure set alongside (which experts will readily understand of themselves, as far as the naming of the points and of the arcs is concerned),

Diagram. A circle (the celestial sphere in projection) with a network of intersecting arcs. The following point-letters are legible around and within the circle:

- A (upper interior): apex point of the triangle (the pole of the equator in the construction)
- C (upper, right of A): point on an arc near the top
- G (upper left, on the circle): point on the circumference
- B (interior, center-left): intersection point
- D (interior, right of B): intersection point
- I (left, on the circle): point on the circumference
- K (right interior): intersection point near the right
- E (lower-center interior): intersection point
- F (lower, on the circle): point on the circumference
- H (right, on the circle): point on the circumference

we will proceed by this law, presupposing the same position of Lyra which he cites (however poorly it may square with the celestial situation of this star), and likewise the same right ascension of it, and the declination, which he rightly applied to the assumed longitude and latitude; and the arc of the equator between the two observations, passing through the mid-heaven, will be the object of our hunt.

[which experts will readily understand of themselves], first considering the triangle A B C. Here A C is the difference of the poles of the horizon and of the equator, $38^{\circ}18'$; and B C is the complement of the declination of Lyra, $51^{\circ}19'$. The third side, B A, derived from the complement of the altitude at the first observation, is $48^{\circ}25'$. Therefore, since in the said triangle all three of its sides are established, the angle A C B cannot remain unknown: it comes to $69^{\circ}1\frac{1}{2}'$, and it

measures the arc G E — namely, the equatorial difference from the right ascension of Lyra, near E, up to the right ascension of the mid-heaven, near G. This arc, then, added to the presupposed right ascension of Lyra, $275^{\circ}5'$, gives the right ascension of the mid-heaven as $344^{\circ}6\frac{1}{3}'$, which he, proceeding in the same manner — having neglected at least a third part of a minute — designated. Then in the other triangle A D C, since again three sides are given — A C, as before, and D C, likewise the complement of the declination, as before, and now D A, the complement of the altitude of Lyra, being $56^{\circ}9'$ — the angle A C D is found, $82^{\circ}5'48''$, which, again added to the right ascension of Lyra, yields the right ascension of the mid-heaven, $357^{\circ}10'48''$. This, within a few seconds (which he seems to have neglected deliberately), agrees with Nolthius's computation. Hence, if we now subtract the smaller right ascension from the larger, we shall learn the arc of the equator that has passed across the meridian in the meantime: $13^{\circ}4'28''$, which he established at fully five degrees and minutes, larger by at least half a minute (a matter of no consequence). And this it was that we first set out to examine.

Now we will go through the rest, as far as it concerns the parallax, derived hence and from the presupposed observations. Nolthius, it is true, does not indicate by what method of demonstration he gathered this, beyond the drawing of the figure itself; yet it is plain enough that he proceeded in accordance with the third problem of Regiomontanus's [Regiomontanus] little book on the measurements of comets. And this is the more likely in that he asserts, from the outset, that he had diligently studied these problems. I will therefore fit Regiomontanus's construction adduced there, with its demonstration, so far as it bears on the present phenomenon, and the parallax will thence be investigated in this way.

Let it be understood that, in this figure, the arc O G is the azimuth of the observed star, $60^{\circ}0'$. Let the quadrant of altitude from this azimuth at G, passing through the apparent and the true place of the star, be B G;

Diagram. A circle (celestial sphere in projection) with several great-circle arcs crossing it. The legible point-letters, arranged around and within the circle, are:

- A (upper right, on/near the circle): pole of the equator
- B (upper, left of A): point on the upper arc
- C (just below B): point on the arc
- D (below C, interior): point on the arc
- I (left, on the circle): point on the circumference
- N (left interior, below I): point

- K (interior, center-left): intersection point
- L (interior, below K): intersection point
- H (right, on the circle): point on the circumference
- O (lower-center, on/near the circle): point
- G (lower-right interior): point
- M (lower right, on/near the circle): point on the circumference

so that on it the apparent place is at D and the true place at C. Let there further be drawn, from the pole of the equator A, two quadrants through the said places, as far as the equator, and let A D L pass through the apparent place, and A C K through the true place. The arc C D, then, in the vertical circle, will be the parallax of altitude, which is intercepted by these

by these two quadrants. We shall elicit it in this fashion.

Since the arc of the equator, which was meanwhile being completed by the motion of the universe while the star moved from the first observation up to the meridian, is established from both — the altitude of Lyra then likewise taken being, as is clear from the foregoing, found to be $13^{\circ}5'$ — this will be equal, in triangle B A C, to the angle of that triangle which is at A. For just so much of time and of equatorial space was required, from the true place of the star at C up to the meridian, as the altitude of Lyra furnished, on both sides, in the prescribed manner. The other angle, A B C, is offered from the complement of the azimuth at the quadrant — namely G H — as $30^{\circ}0'$. The side adjacent to these two angles, B A, from the difference of the poles of the horizon and of the meridian, is ready to hand: $38^{\circ}18'$. Therefore the remaining two sides will be needed no longer; and, the operation completed, C A will be $28^{\circ}11'$ [13. B C, $12^{\circ}21'$]. Now A C measures the complement of the true declination, whence this works out to $61^{\circ}48'47''$. And this agrees well enough with the Nolthian finding. The other side, B C, discloses the complement of the true altitude, that is, its distance from the zenith. This, subtracted from the observed distance from the apex — which was $13^{\circ}0'$ — produces the arc C D, the parallax sought, $0^{\circ}39'$, the very same, to the very minute, as the one he put forward.

Yet even though these results stand a little differently if we apply the true place of Lyra, according to our restitutions, to the remaining data — nevertheless the difference is exceedingly small. But that this too may become clear, we will dispatch it briefly, from the figures already drawn, and by the same method of demonstration.

Our place of Lyra at that time was $9^{\circ}19'$ Sagittarius [♐] in longitude, with the latitude of it coinciding at $61^{\circ}47\frac{1}{2}'$; from this its right ascension comes out at $275^{\circ}36'$, and its declination at $38^{\circ}27'$.

Repeating, then, the first figure here, and its procedure, in triangle A C B the side B C — the complement of the declination of Lyra — will be $51^{\circ}33'$. The remaining two as before. And thus the angle A C B comes out as $68^{\circ}46'34''$. And consequently the right ascension of the mid-heaven is $344^{\circ}22'34''$. In the other triangle A D C, the sides C A and D C stand as before. But the side D A is from Nolthius's observation, $56^{\circ}9'$. The angle A C B is therefore investigated as $81^{\circ}49'29''$. And on this account the right ascension of the mid-heaven is $357^{\circ}25'29''$. Comparing now the two right ascensions, their difference is found to be $13^{\circ}2'55''$. This is smaller, by two minutes and 5 seconds [$2'55''$], than the one Nolthius worked out before; and this comes about from the truer assumed place of the star.

Hence, in the other figure, the angle B A C will now come out of the same magnitude as well — namely $13^{\circ}2'55''$; and in the same triangle the side C A, the complement of the declination, will be $28^{\circ}12'23''$, so that the true declination is $61^{\circ}47'37''$, differing from Nolthius's finding by about a sesquialterate minute [$1\frac{1}{2}'$]; and the side B C will yield

$12^{\circ}19\frac{1}{2}'$. When this is subtracted from the observed distance from the apex, B D, $13^{\circ}0'$, there will be disclosed the parallax C B which we were seeking: $0^{\circ}40\frac{1}{2}'$, still larger by a sesquialterate minute [$1\frac{1}{2}'$] than the one Nolthius established. Yet this differs only slightly — indeed, imperceptibly.

From the aforesaid examination, then, it becomes evident that Nolthius carried out the procedure of a competent demonstration upon the numbers not inelegantly; nor can anything of any moment be detracted from this on the grounds of a more correct place for Lyra.

It follows, accordingly, that in the very data and observations of Nolthius there lies no slight error — something that could easily have come to pass for a man not long or much practiced in this arena, and lacking refined instruments, especially in matters so slippery and so prone to lead one astray.

And to what end, I ask, was he seeking a knot in a bulrush, when by a far smoother and surer road it was open to him — from each of the star's altitudes, greatest and least, with the elevation of the pole brought in — to arrive at a decision about the parallax? But if it pleased him to make for this point by such roundabout ways, why did he not rather turn to the star when it was in a lower position, where (if it had any at all) it would exert a greater parallax, and would

render this more observable? Did he attempt that? No — for it was less fitting, in so lofty an altitude — differing scarcely three degrees from the highest, which occurred at the meridian — to scrutinize these matters, since the parallax was then not merely almost minimal, but even slight and imperceptible; and a leaning of the instrument away from the true vertical plane could so distort the azimuthal angle that the rest would be built up less securely. And why, too, did he take so narrow an interval between the two observations, when, with the star far more lacking proper motion — and so contributing no defect on that score — it would have been more suitable to choose a wider one, for recognizing the parallax more readily and surely? How, moreover, could it have come about that, in the very same instant in which both the azimuth and the altitude of the star were being taken, and its transit across the meridian was occurring, one and the same observer should at the same time also explore the altitude of Lyra, so that — in so great a rapidity of the *primum mobile* — no discrepancy should arise?

And surely some little variation in the altitude of this star altered the arc of the equator passing across the meridian by much more; and therefore the parallax that was being sought could come out far otherwise — or rather not at all, if everything had been administered without any error. I pass over now the fact that, from the altitude of Lyra, it was not safely enough possible to perceive these quantities with the precision that was required: from which the change of its altitude would be smaller and slower than what would satisfy the much faster motion of the equator. It does not seem, then, that Nolthius brought to bear in these matters the circumspection that was altogether required in so subtle a business; and without doubt he used instruments that were playthings, childish, and unsuitable. This is clear from the very fact that he reckons both the azimuth and the altitude...

would place the star at whole, complete degrees, with no minutes attaching to it here or there. For granted that he acted deliberately in fixing the quadrant at some full azimuthal degree until he had ascertained the coinciding altitude of the star — so as not to have to attend to both azimuth and altitude at the same time — still he will hardly convince anyone that the altitude itself also fell at that moment on some whole degree without any minutes. One may reasonably suspect that this is rather to be charged to a defect of the instrument.

But if it proved nothing else than that Nolthius's [Andreas Nolthius] observations are riddled with excessive error, it would be quite enough to settle the point. From here it emerges that he makes the right ascension of the star [*recta ascensio*] $357^{\circ}11'$, before the vernal intersection [*intersectio Verna*] $2^{\circ}49'$ —

though in truth it exceeded this figure in minutes by at least 26 (as is clear from what was demonstrated in Cap. 5). Thus, in the right ascension, where it should have been determined, Nolthius committed an error of $3^{\circ}15'$. And how was he to track down without all doubt a parallax, which is a far more obscure matter? He must therefore not even have drawn the meridian line properly — which in itself is not so very difficult to find, and an exact knowledge of which was very necessary here, let alone to have carried out the measurement of azimuth and altitude without error. It could thus well happen that in each of these matters he unwittingly committed some error, and that, magnified and multiplied, this made the parallax he attributed to the star so far off the mark.

For to capture azimuths and altitudes at once without any miscalculation, and likewise to determine the moments of time subtly at the very same instant (to say nothing of the exact placement of the meridian), requires diligence and circumspection, together with an instrument perfect and well-ordered in every respect — such as Nolthius, perhaps, or anyone else who has not exercised these labors through long experience and recalled them to the anvil of truth, may not have had it occur to him. And if Nolthius himself, or anyone else, doubts on this score, let him likewise undertake, just as that man did, the same kind of test on any of the fixed stars: assuredly, unless he carries the work through with greater care and by other means, he will then go on falsely to assign to the fixed stars as well — which are entirely free of it — a parallax no smaller than the one he assigned to this New Star [Nova Stella], and will arrive at a result equally great, indeed of no smaller absurdity.

Moreover, if this New Star at altitude 77° had yielded a parallax of $39'$, it would have made it four times greater at its lowest descent, when it was being raised there to $23\frac{3}{4}^{\circ}$. Such a wandering shift would certainly have been most easily detectable even by the naked eye, without any instrument, simply by reference to the neighboring fixed stars.

But to make better known — more readily and more surely — what we just said, namely that an enormous and intolerable parallax follows at the nearest altitude from Nolthius's measurement, we shall make this very point plain in the following figure, resolved into numbers geometrically.

Diagram. A quarter-circle (quadrant) construction representing the geometry of the Nolthian parallax. Center A lies at lower left, with the horizontal radius A–G running to the right along the true horizon and the vertical radius A–E running up toward the zenith; the curved arc E...C...D...G sweeps from top to right. Point B sits just above and right of center A on the radius toward the star; point C is high

on the arc (the star's position at altitude 77°), point D is lower on the arc (the star at its low altitude); F lies on the base line A–G just right of A. Straight lines are drawn from A and B to the arc points, forming the triangles described in the text.

- A (lower left, center): center of the Earth (A = center of the Earth, B–F)
- B (just above/right of A): point on the line toward the star, marking the apparent position seen from the Earth's surface
- C (high on the arc): the star as observed at altitude 77°
- D (lower on the arc, right side): the star at its low altitude
- E (top): upper terminus of the arc / direction of the zenith of the chapter [Zenith Capitis], A–G [recte A–E]
- F (on base line, right of A): foot point on the horizon line
- G (lower right): terminus of the horizontal radius on the true horizon

Let A here be the center of the Earth, B–F a quadrant of its surface; let A–E look toward the zenith of the place [Zenith Capitis], and A–G toward the true horizon. Let the quadrant E–C–D–G be removed from the Earth by just as much as the parallax of the Nolthian comet requires. And let the star lie near C, when it was observed at altitude 77° . Then, with lines drawn from the center and from the vertical circumference of the Earth, there will be a triangle B–C–A, with all its angles given. For the angle B–C–A, which measures the parallax at the said altitude, is, in Nolthius's opinion, $0^\circ 39'$. The angle A–B–C is the complement of the apparent distance from the vertex to two right angles. And since the angle E–B–C, which represents it, was observed by Nolthius as $13^\circ 0'$, the said angle comes out as $167^\circ 0'$. The third angle, B–A–C, is the complement of these two to a semicircle, that is, to two right angles, as is clear from the *Elements* of Euclid. Therefore, since the two prior angles taken together amount to $167^\circ 39'$, the angle B–A–C — namely the remainder up to 180° — will come out as $12^\circ 21'$.

So, as I said, all three angles are fixed. The side C–A therefore cannot escape us. For taking B–A, the Earth's semidiameter, as 860 miles, the side A–C will, by their relation, come out as 17,053 — the distance of the star from the center of the Earth according to Nolthius's positions. Next, let this same star be understood as near D, at its low descent; and with lines again drawn here from the surface and the center of the Earth, just as before, there will be in the triangle B–D–A a side A–D equal to A–C itself (found by the same method, since they proceed from the center of the same sphere or globe of equal distance). And since B–A, the Earth's semidiameter, is known, let the angle B–D–A be found by this rule: the true declination [declinatio vera] that the Nolthian computation gave was $61^\circ 49'$; the complement of this — its distance from the pole — therefore comes to $28^\circ 11'$.

Subtracting this from the elevation of the pole, which he sets at $51^{\circ}42'$, the true minimum altitude of the star comes out as $23^{\circ}31'$, signified by the angle D–A–G. Therefore B–A–D, its complement up to the side of the quadrant, must be $66^{\circ}29'$. And so, from the two known sides together with the intercepted angle, the angle B–D–A comes out by inference as $2^{\circ}42'$. This furnishes the parallax of the star at its nearest approach to the horizon, which is what I was seeking — and which is somewhat more than four times greater than the one Nolthius attributed to altitude 77° , just as I intended to prove.

If, then, this New Star had been liable to so great a parallax, it would surely have been removed from the eleventh star of Cassiopeia [Cassiopea], its near neighbor, when it was at its most depressed — by about one and a half degrees, that is, by three lunar diameters [diametri Lunares], below the said star toward the horizon — even though it stood at that time very nearly the same distance above it. And at its greatest altitude it would have been seen under this same star by about 2° . Whereas in truth, both as to distance and as to declination...

it kept exactly the same arrangement with respect to the said star, both at its greatest and at its least altitude, so that it preserved an unbroken observed relationship not only with this star but also with the other stars of Cassiopeia — as is attested by the things we recounted in Cap. 6. For the same was everywhere true of the rest of the fixed stars too, and especially of its remoteness from the Pole Star [Polaris] throughout its whole revolution: which more witnesses than one were compelled to admit even from bare visual inspection. And this could in no way have happened if it had exhibited so great and so variable a parallax. Indeed, the difference would have come out so evident that there would have been no need of instruments to measure it, but anyone who had even a moderate acquaintance with the stars could, by sheer eyesight, have discerned this reciprocating wobble of the star as it varied throughout its whole revolution. The falsity of this matter — and of all the rest, which we reviewed in the two preceding chapters — is abundantly refuted by the observations. Among those refuting it is also the most illustrious Prince himself. From the very beginning the Prince's animadversions were arrived at with far greater diligence and by sounder, more exact instruments than these Nolthian ones, accepted on top of them, which scarcely yielded 3 minutes.

They attributed the parallax to the lowest elevation. So that even by the Prince himself — to whom Nolthius dedicated his work, whose judgment, drawn from observations that he saw with his own eyes, and whose instrument bear witness — Nolthius is convicted as a man out of his senses. I cannot wonder enough that

he was not ashamed to offer something so feeble, and so foreign to all certainty, to this Prince — who contemplated and judged the whole matter far more accurately — and to appeal to him, as it were, as an arbiter. And what is most unseemly: he tries to establish the Aristotelian fictions about comets, more vaporous and evanescent than the very smoke-clouds out of which he builds them, by means of astronomical observations — and thus to approve falsehood, to contaminate astronomical and geometrical certainty and abuse it, and to contradict the most manifest experience, which shows the opposite; or else, being himself ignorant (for I would not believe he did this on purpose, in order to defend the inveterate Aristotelian opinion in which he had been steeped), he too rashly presumed. So that it must be lamented, Nolthius — otherwise no unlearned mathematician — published things so monstrous, and so at odds with reality, concerning this star, by which, under the pretext of astronomical observations and a demonstration and calculation deduced from them, he bewitches the unwary, and makes it easy to cover over and confirm an error too inveterate and too long received — not only as to this star, that it was sublunary, but also as to all comets. Had he kept silent and suspended judgment until he could be taught something more certain, he would surely have done better, and would have better upheld the part of a philosopher and mathematician who loves the truth.

Let this Nolthian parallax, then, be gone — so far wandering from the whole heaven — by which he attempts, with feeble strength, to drag down a star exalted above the orbits of all the planets, and fixed in the eighth sphere [sphaera octava] (as they call it), into the sublunary air, against all right and justice. Meanwhile, however, the things he builds upon this in the three following chapters, however equally feeble they may be...

together with the aforesaid fragile and ruinous foundation, we shall not omit to examine and weigh.

In the fifth chapter [Capite quinto] he sets out to elicit the star's longitude and latitude from the previously found right ascension and declination. And he establishes a distinction between the true place and the apparent place — which would indeed have to be made, if so evident a parallax as he supposed had been present. Yet here he did not administer the calculation as carefully as in the earlier ones. For while he fixes the true right ascension at $357^{\circ}11'$ and the declination at $61^{\circ}49'$, he gathers from this the comet's true longitude as $5^{\circ}4'$ Taurus [♉], and its latitude as $54^{\circ}48'$. But we, from the same data, presupposing also the same maximum declination he used, $23^{\circ}28'$, find the longitude to be $4^{\circ}57'$

Taurus — its position 7' earlier than his. Our calculation gives the latitude as $54^{\circ}52'$, four scruples greater than his annotation. And just as in longitude, so also in the apparent latitude, his reckoning agrees less exactly with ours. For while he sets this longitude at $5^{\circ}57'$ Taurus, together with a latitude of $55^{\circ}0'$, we find the longitude almost 8 scruples further on, and the latitude 5 scruples less.

But if all of this is handled according to our restitution in the place of Lyra [Lyra] — from whose altitude, together with its difference, the right ascension of the midheaven [medium Caeli] is taken and adjusted — the true right ascension of the star will come out as $357^{\circ}25\frac{1}{2}'$. And the true declination too will be $61^{\circ}47\frac{2}{3}'$, to which corresponds a longitude of $5^{\circ}8\frac{1}{2}'$ Taurus and a latitude of $54^{\circ}44'$. But the apparent right ascension for us is $358^{\circ}23'$. Applying to it the apparent declination as well, $62^{\circ}18'$, the apparent longitude will come out as about $6^{\circ}18\frac{1}{2}'$ Taurus, and the latitude of the same as $54^{\circ}47\frac{2}{3}'$. And according to this examination, his parallax of longitude was $0^{\circ}53'$, though it ought to have been about $1^{\circ}8'$. Moreover, our reasoning, established for the certain place of Lyra, gave a difference of longitude of $1^{\circ}10'$. So too in the parallax of latitude he has 12', whereas our calculation yields only 3'; and according to our more correct method, it would be $3\frac{1}{3}'$.

From these things it is clear, as we said, that Nolthius did not bring to bear, in the true places and in the proper reckoning of what is seen, the same diligence as in the earlier matters. Nor, however, do I call these things back onto the anvil of numbers on the grounds that they are of any moment, or that the intervening difference makes any difference to the matter; but only in order to test whether the Nolthian calculation held exactly to the mark. Indeed, to tell the truth, this whole business is frivolous and useless. For since this star exhibited no parallax at all, its true and its apparent place did not differ in any respect either, but throughout its whole revolution coincided in one and the same point, because the Earth's semidiameter had no sensible magnitude relative to its distance. In vain, then, does Nolthius torment himself in laboring to find the distinction between the true and the apparent place. Whether he even carried this through with sufficient scrupulousness from his own data [Dedomena] may be doubted. Indeed, what is more...

by which it is greater. As for its longitude, the position he assigns is too far advanced by almost two whole degrees; and in latitude it overshoots by more than a full degree. So how can a man who assigns the star a position so far astray deserve any credit for having correctly determined its parallaxes, which call for a far finer and more difficult investigation? And just how seriously he has erred in

these matters will be readily apparent once one compares his figures with the position of the New Star [New Star of 1572] that we established in many ways in Chapter 5. But since all of this rests on a faulty starting point and on false data [dedomenis], it is no wonder that one absurdity should breed many more. So I will leave these aside and examine the following chapter in the same way.

In **Chapter Six**, from the false parallax he has assumed, he sets the distance of the star (which he improperly calls a comet) from the Earth at 19 Earth-radii [Semidiametri Terrae], together with 50 minutes and 12 seconds. And see how precisely he supposes he has found the answer! He does not even hesitate to add the seconds, when across the whole vastness of the heavens—incredible in its magnitude, and against which the entire Earth, set beside it, has no perceptible proportion whatever—he has gone astray. Now, resolving this distance into German miles, and taking the Earth's radius at 860 miles, he determined that it stood off from the Earth by 17,059½ miles; and even here he is anxious that he may be in error by half a mile—when in fact he has wandered off from the true distance, which is that of the Moon, or rather some twelve Earth-radii below the Moon, all the way up to the eighth sphere [sphaera octava].

It was easy, however, to gather this distance—erroneous as it is in the extreme—from the parallax he had assumed. For in the configuration of triangle BCA set out just before, all three angles are determined: the angle ABC is the complement of the observed altitude up to the semicircle; the angle BCA is the assumed parallax itself, P.O.[?]/39; and the third, BAC, is the complement of these two up to two right angles. Therefore, since BA—the Earth's radius—is known, CA, the distance from the center of the Earth, can also be found in the same units; or, by distributing AB into the miles assigned by the geographers to the Earth's radius, AC will likewise come out in those same miles. Once I had carried out the calculation, I found no discrepancy from Nolthius's result that was of any moment. So I pass this over, since for its very slight deviation it does not deserve further consideration.

In **Chapter Seven** he reports that he measured the apparent magnitude of this star with a radius [Radius] and found it to be 10 minutes—which is utterly incorrect. This star scarcely matched four minutes in its visible diameter, far from being three-and-a-half times larger than that, unless perhaps he measured the rays darting out on every side from its body, taking them together on both sides. But how that could be done accurately I do not see, since the outer edges of those rays could not be made out. Nor did those rays belong to the substance of the star itself; rather, they arose merely from a vibration of the light, just as

happens with the other brighter stars and as they appeared to us. And it is not unlikely that Nolthius took these rays, however

received, to be part of the body's own substance—from which he had no hesitation in making the star's hair-like rays into something resembling the round shape of comets.

But let us grant that the visible diameter of the star—which he calls "hairy" to no purpose—was 10 minutes, and that its distance from the Earth was $17,059\frac{1}{2}$ miles, as he gathered in the preceding chapter. Even so, his result does not yield its true diameter with sufficient precision: he concluded it to be 46 miles and $49\frac{2}{3}$ hundredths [M.49 $\frac{2}{3}$], whereas it works out rather to $49\frac{3}{4}$ miles. This will easily be clear by multiplying the sine of 10 minutes, which is 29,088, into the assumed miles, and dividing by the whole sine: the result will be $49\frac{3}{4}$; and the same comes out if one proceeds in another way. For since the doubled diameter of the circle of the comet's distance is 34,119 (and seeing that every diameter stands to its circumference as 7 to 22, very nearly), the circumference of that same circle will accordingly be $107,231\frac{1}{2}$, which—if it be understood as divided into 360 degrees—will assuredly take up a sixth part of one degree as its visible diameter, which he sets at $49\frac{3}{4}$ miles; and so a threefold amount, roughly, will be wanting in his own calculation.

But to what end do I examine these matters so minutely, when they stray utterly far from the truth itself—not by some few miles, but even by several whole Earth-diameters? This is plain from what we demonstrated in Chapter 7. For there, from the assumed visible diameter of the star—at least $3\frac{1}{2}$ minutes, since it could be no smaller—it is clearly established that its true diameter contains the Earth's diameter a little more than seven times over, and that its whole bulk was greater than the terrestrial body—at the very least, three hundred and sixty times greater (granting that he calls the star, or comet, smaller), and at the least it makes the Earth nearly fifty thousand times smaller. How, then, will Nolthius's paltry magnitude—reckoned in our own at about two hundred and sixty times the true diameter—square with this? And all of these results, which depart so monstrously far from the mark of truth, here as in the two preceding Nolthian chapters, had the source of their error in this: that in Chapter 4 he assigned this star so monstrous and enormous a parallax. Yet this excessive ineptitude of the parallaxes did not arise from the demonstration and the calculation built upon it (as we have hinted above as well), but from the very data, gathered from the outset through faulty observations—which came about partly through the fault of

instruments not accurate enough to perform this task, and partly because he did not carry out everything required with sufficient care.

Let those, then, who wish to bring out something of this sort before the public first learn—through long deliberation, practice, and use—to carry out celestial observations without any blundering, and to procure for themselves means or instruments that are of proper size, made of solid metal, and in every respect elegantly and accurately fashioned. If they are not equipped with such, it will be far better for them to refrain, and to commit nothing to paper rather than what is false and leads away from the truth—lest, with the loss of truth, they lose the approval they aim to win sooner than they gain it; and lest afterward,

once they have been convicted of error, they be led by too late and useless a repentance to prefer that all of this be tainted. As for the present case, I have no doubt at all that this man Nolthius, once he had learned from the more reliable observations and demonstrations of others how gravely he had stumbled, would have wished he had never done it, and would have longed that it had not been published—provided only that he is a sincere lover of truth (of which I am confident in his case) and does not stubbornly conceal and defend his own errors.

Finally, in **Chapter Eight and last**, he brings in astrological predictions about the effects of this phenomenon; but how much weight these are to be given is easily judged from what has gone before. For when he has handled so erroneously and incompetently those very things that lay open to the senses of the eyes and to sure demonstration and observation, how will he attain established truth concerning matters that do not fall under the senses but rest at best on probable conjectures? And since astronomical matters serve astrological ones—so that the latter cannot stand without them—and since the astronomical claims, which are otherwise known with certainty, were in his case false, how much more will the astrological ones, of themselves full of empty notions and errors, stray beyond all moderation, away from the truth? It should be no wonder, then, that Nolthius has undeservedly fastened on this phenomenon so many and such great effects—effects which, however, in all the years now elapsed, no experience has confirmed, unless perhaps those things which otherwise commonly occur amid the vicissitude of human affairs and the unstable, ever-shifting fortune of earthly things (as for the most part they tend to happen) he wishes to attribute to the portents of this star, taking what is not the cause for the cause—which is commonly done and is far too much in use among astrologers. But since to weigh conjectures of this kind and to add my own judgment to them is foreign to my purpose, I am unwilling to take up one by one the Nolthian prophecies, which he

tries in vain to prop up with the authority of Ptolemy [Ptolemy]—who spoke, at least, of genuine comets (and not even of these in a way solid enough to meet the demands of the matter)—and to pronounce censure on them; especially since this would make the astronomical consideration of so admirable a star, already handled far too thoughtlessly, by way of a colophon turn out empty and suspect under an astrological uncertainty no smaller, if not greater.

So, leaving this Nolthius and his followers with their decisions—both astronomical and astrological—about this star so little exact, let us go on to examine and call to the scales what the rest have brought forward, men who ignorantly make a sublunar [sublunar] comet of it.

GEORGIUS BUSCHIUS, CITIZEN OF ERFURT [Georg Busch]

It is fitting to append Busch's description of the new star to that of Nolthius, because he too held the opinion that this was a comet and that it blazed in the upper air—so much so that, although the observations he himself made he did not adequately

understand, they nonetheless point the other way. For these observations place it far above the sphere of the Moon, within the limits of the ethereal world. But because, through his lack of skill, he was unable to use them correctly and wrongly pronounced the star a sublunar comet, he must be reckoned among those who have put forward matters too unskilled and unfit concerning it; otherwise, had he learned to use his own observations rightly, he would deservedly have been ranked among those we treated in the preceding chapter. Nor, because he practices the mechanical craft of the painter's art, should one disparage him so far that he does not also deserve a place among certain learned men who have written something about this star—especially since he is eager for astronomy and, as he himself reports, has studied it for twenty years and has brought forward not a few observations. Although these were obtained with less than due accuracy, with an instrument that, while of the kind one ought to use, is by no means free of fault, they are nonetheless not wholly to be despised; indeed, in some respects they may be preferred to certain others noted earlier. Nor should the art of painting, even though it is in larger part mechanical, be reckoned among the wholly illiberal arts: rather, it is a kind of middle thing, sharing in both the liberal and the manual arts—

since in geometry, optics, and perspective it has its foundations, which are rightly assigned to the mathematical sciences. And so Dürer [Albrecht Dürer], and indeed certain others well versed in part in these subjects, came out the more

distinguished craftsmen in the art of painting. It must therefore be counted not a fault but rather a credit to this man Busch that, although he is a painter, he has nonetheless devoted his effort to mathematical and astronomical matters, according to his own measure, and has published his speculations on this phenomenon as well. And should any object against him that he is perhaps not very skilled in the Latin tongue, and that on that account he ought not to be ranked among the learned, this is our answer: knowledge does not consist in words but rather in the understanding of things; nor does it matter in what language something is expressed, provided the thing itself, rightly understood, holds good by proper reasoning. And if Italians were permitted to write about this star in Italian, why not a German in German—since the aforementioned Nolthius did the same, although he was well enough versed in the Latin tongue? Let the rest, then, who pride themselves on the title of learning, allow this man Busch to hold some place among them. For it is not so much to be considered who has said a thing as what is said. For now and then even the gardener (as the proverb has it) has spoken to the point. Moreover, his observations are sometimes cited by Thaddaeus [Thaddaeus] and certain others, and carefully weighed. This alone I find wanting in him: that he did not measure this star with larger, solidly made, and more reliable instruments; and above all, that with these very observations—of whatever kind—once he had received them, he neglected through ignorance to build up something truer than he did.

He published two writings in the German language about this star, which contain much in the way of words, but little of substance and solid knowledge.

And so, leaving aside his verbose and largely irrelevant circumlocutions, I will touch briefly on certain principal points that seem to be of some importance.

In his earlier pamphlet [Busch] calls this star a comet, and assigns it a sublunar location, attributing it — in the commonly accepted manner — to dry and viscous matter of the exhalations ignited in the uppermost air. But this error and lack of skill can readily be excused in a man of little learning, since even those who profess philosophy in the schools propose the same thing, and are no less blind on this point. We, however, shall pronounce a very different verdict in the books on comets that follow, and through sound observations and unassailable demonstrations we shall vindicate those bodies from the great injustice and falsehood under which they have labored for about two thousand years, since the time of Aristotle [Aristoteles] — who chiefly provided the occasion for this error — and we shall restore them to their proper place, that is, to the celestial world. For this reason I will not set up any longer discussion of these matters here. That

this star was not a planet will be readily granted; and likewise, that it was not one of the number of the fixed stars can be conceded without difficulty, if we have regard to bodies coeval with the world. But the reason he adduces for why it should not be counted among the stars of the eighth sphere [sphaera octava] — namely, that it was subject to a wandering and erratic motion — is contrary to the truth. For it remained perpetually fixed in the same place in the heavens, throughout the whole time of its duration, never departing from it by so much as a single minute or more. This was observed not only by us, but also by very many others.

In vain, then, and without any sound observation, did he assign to this star some motion, though he never determines what sort of motion it was, how great, or in what direction it tended — except that he says it afterward moved somewhat retrograde toward Cepheus. But this in no way happened: rather, this wavering, this erratic shifting back and forth, lay in Busch's [Buschius] own eyes and instruments, not in the star itself, which truly underwent nothing of the kind. Since, therefore, he falsely attributed this change of place to the star, and the contrary is the truth — namely, that it stood perpetually fixed in the same position — it was more probable that it had found a place among the stars of the eighth sphere, higher than the planets themselves, rather than that it hung in the elementary air, subject to manifold mutability.

The second argument by which he tries to prove that the comet was sublunar and not an ethereal star — namely, that it was also seen by day from the very beginning — is equally frivolous and, like the previous one, false. For the fact that this star was visible during the daytime in the first months, in clear sky, came about because of its size and brightness, and because it was set far from the solar path, removed toward the north, and therefore was less obscured by the Sun's rays. Nor on that account was it to be reckoned some torch glowing in the air; otherwise the planet Venus too would not be counted among the celestial bodies, since it likewise is often seen

together with the Sun, when the Sun stands high enough. Indeed, from this very fact he had no just occasion to associate this star with the number of comets, since comets are nowhere recorded as having been seen by day, or at most very rarely. Add to this that this star was not seen perpetually, for as long as it lasted, by day: but only around its first beginnings, when (as I have said) it shone more brightly. Afterward it began to show a decrease in size and light, and, reduced to the likeness of a star of the first or second magnitude, it was no longer visible in the daytime. Was it then sublunar in the first months, when it was discerned by

day in the air, but in the later months — when this was no longer granted — did it migrate into the ether among the remaining stars? But that this star was a comet Busch did not sufficiently prove, much less that it was sublunar (which he falsely attributes to comets as well). And although I will grant him this much — that it lacked a tail — that is not enough to convince me it should be exempted from the class of comets; for some have been found to shine without a beard, such as the one we observed in the year 1585. Nevertheless, in concluding from this that it belonged to that species of comet which they call a "rose" [Rosa], he is greatly deceived.

For it had no streaming hairs spread all around, nor did it have the same form that the ancients assigned to the comets they call roses: there was no broad and ample roundness, blazing and fiery, emitting from its edge thin and rather dim rays; rather, it appeared most like genuine stars, in no way discrepant from them in form. It was equally clear and pure around its margin, and in the rest of its intervening body it vibrated rays and sparkled like the other fixed stars. As for what he says — that when it approached the horizon it shone forth with certain marvelous and astonishing bursts of flames and radiations — that is entirely without certainty. For we never observed anything of the kind in it, whether it stood lower or higher, throughout the whole time of its duration, however long and intently we kept watch in scrutinizing its appearances. Nor was anything of the sort noted by anyone else who handled the matter carefully and faithfully. Therefore, if Busch saw any such thing in it, it must have happened by accident, through vapors hovering about the horizon and interposed between the star and ourselves when it was lower. So he wrongly imputes from this a cometary nature to it.

For if it were permissible to reason this way, then surely we would have to withdraw the Sun and the Moon and the rest of the stars from the heavens into the elementary air, and from there fashion them into comets, whenever — through the interposition of vapors, especially near the horizon — they sometimes display their form and color in an unusual manner. But I judge that he, by license of the painter's art rather than the astronomer's, depicted these things: hence in the later figure represented in his treatise he painted in swords and spears and hairs alongside it, wishing perhaps, out of his own painter's art, to embellish it otherwise and to strike the eyes more by a more terrifying form,

than the heavens themselves displayed. But it would have been altogether better had he kept these inventions and pigments to himself and to the exercises of his own draftsmanship, and not contaminated with them a star that shone

everywhere with pure light and was in no part discrepant from the other genuine stars in respect of form, nor admitted anything foreign. For thus he would have played the part not of an artful painter, but rather, and more correctly, of a truthful writer.

But truly — not to dwell long on it, before we uncover Busch's errors regarding the situation and nature of this star — let us now show, even from his own observations, how enormously he went astray.

He says that with the instruments he names — among them an astrolabe, a quadrant, and a geometric square — he determined this star in the heavens. But when it comes to the indication of his observations, he has at least these: that he found its greatest altitude on the 25th of November at 7 hours 14 minutes p.m., when it crossed the meridian above the pole, to be 79 degrees 20 minutes; and afterward, on the following day in the morning, around 7 o'clock, its least altitude — when it was again very near the meridian below the pole and the horizon — to be 22 degrees 40 minutes. He sets the altitude of the pole at 51 degrees 10 minutes, the same that Apianus [Peter Apian] in his *Abacus* assigns to Erfurt. And yet from these data it by no means follows — as he supposes — that the star admitted so great a parallax as to make it sublunar. For if we subtract the altitude of the pole, as he presupposes it, from the star's greatest altitude, its distance from the pole, when it stood directly above it, comes out as 28 degrees 10 minutes. Again, if we take the least altitude from the pole's altitude, the remainder will be the star's distance from the pole when it was placed perpendicularly below it, namely 28 degrees 30 minutes. Since, therefore, the lower distance from the pole exceeds the upper by only 20 minutes, the aggregate parallax of the altitude — both the highest and the lowest — could be no greater than just as many minutes, that is, a third part of one degree. The Moon, however, when it is closest to the Earth, at such an elevation above the horizon, causes a parallax of a whole degree. By no means, then, could it come about that this star, producing the parallax observed by Busch — composite as it is — should, at the prescribed least altitude, amount to even a third part of one degree, so as to have existed in the elementary air below the Moon. Indeed, a good portion of a whole degree ought to have increased that same parallax, had the star reached the Moon's concave surface according to Copernicus's [Copernicus] measurement; and still more, if one had to stand by the Ptolemaic [Ptolemaeus] supposition. Nay, if this parallax — as it should be — is disaggregated, since (as I have said) it exists as a thing aggregated and composite, and this is done properly according to the laws of geometry (a matter on which the most distinguished Dr. Thaddaeus [Thaddaeus Hagecius] has treated learnedly and lucidly in his enriched *Dialexis*),

there are owed on this account, to the greatest altitude, about 3 minutes, and therefore to the least at least 17. And this, according to these data, would be the star's true and simple parallax at the altitude

above the horizon nearest it, 22 degrees 40 minutes [recte: $22\frac{2}{3}$]. And therefore it would necessarily be removed from here by about 185 Earth semidiameters [Terrae semidiametri]: far from drawing nearer to us within 52, as happens with the Moon. And thus it would be more than three times farther off than the Moon itself. How much more so, if it had blazed still closer in the air, or in a fictitious element of fire, below the Moon, as Busch supposed, like a fiery meteor?

Therefore from all this it is sufficiently and abundantly clear how absurd and self-contradictory a verdict he pronounced concerning this star, and how unfittingly he assigned a sublunar location to it. He certainly would not have done so had he known how to examine his own observations — however accurate they may be — and to put them to use, deducing from them as he ought. But the commonly received opinion about comets blinded him here, so that he believed this star too to have been a comet — as has happened to many others far more learned than Busch.

If, then, from his own observations — loosely made and obtained, as it appears, through childish instruments (for otherwise he would have investigated the altitudes more subtly than in whole minutes) — no such great parallax is derived as to make this star sublunar: how much less so, had he carried out the whole matter with due precision and diligence?

And if we had attempted to refine these very determinations of his, as the task seems to require, at least seven minutes will be found superfluous in its greatest altitude, and just as many lacking in its least. This could easily have come about through the fault of the instrument and of the sighting [collimatio]. For granted that the altitude of the pole, not competently assumed, may here introduce some impediment: nevertheless, however the matter stands, he made the diameter of the circle that the star described around the pole far too large — since, taken by arc, it could have been no greater than 56 degrees 26 minutes; which, however, he enlarged by nearly a fourth part of a degree beyond what is right, whether by deliberate effort, or by carelessness, or even by a fault of the instrument, or from all these causes concurring. Indeed, if the altitude of the pole is assumed only ten scruples less, so that it is exactly 51 degrees of arc — as the *Table of Germany* by Münster [Sebastian Münster], revised by Tilemann Stella [Tilemann Stella] (which in most respects does not displease me), supplies it — no parallax of the star will emerge at all from these very altitudes. And yet, by this reckoning his

distance from the pole, or the complement of the declination, will not be satisfied. For it was in reality 28 degrees 13 minutes, both above and below the pole. It is necessary, then, that in all these data some fault lies hidden, so that not even the altitude of the pole itself stands correct: at which I marvel that Busch did not [determine it] from a sure observation, since (as he says) he had been engaged for so many years in astronomical exercises, but instead derived it merely from Apianus's [Peter Apian] common and erroneous position — from which no astronomical observations of his can have that certainty

in altitude and in usefulness, unless above all else something definite has first been established about the exact elevation of the pole.

It is clear, then, how carelessly Buschius [Georg Busch] has handled so subtle and difficult an investigation. And would that he were not the only one to whom such uncertainty—not so great nor so long-lasting—about the motions and positions of the stars must be charged, both in the case of this Star and in other astronomical observations.

As for the rest: regarding the Star's right ascension [ascensio recta], in saying that it culminated with the first degree of Aries (as he reports), he said nothing absurd—provided that, by dividing the matter somewhat more finely, he understood the middle of that same degree. Likewise, in giving the Star's longitude in the ecliptic as 6 degrees of Taurus [♉], he does not stray far, if he means that degree taken as complete, without the surplus minutes—since these were in fact 54, and had almost filled out the whole degree. He would therefore have done better to refer the Star's longitude to the seventh degree of Taurus [♉]. But for someone carrying this out by a mechanical globe—especially when the positions of the stars are not marked on it in exact agreement with the heavens—it was scarcely possible to determine its longitude more precisely.

As for the places on the terrestrial globe over which he reports this Star to have stood at the zenith in its daily revolution, I shall not say much, since the matter is hardly worth the trouble in itself. This much I will add: the Star, in my account, was in no way at the zenith of our Denmark (as he asserts), but declined six degrees from our zenith even when it was at its highest. And so it stood at the zenith, perpendicular over the regions of Norway and Sweden, which lie at about 62 degrees; for it appears overhead there when the pole has been raised, since the Star was higher than the pole on the meridian. But all of this bears on the astrological predictions that he subsequently appends, and I pass it by. For I will say nothing of the trifling prophecies that he afterwards heaps up so copiously,

since they are far too frivolous and are built upon a baseless foundation—and they wander from our undertaking much further than is right.

In the other little book that Buschius published on this same phenomenon—still more copiously than before, and dealing with this Star in words rather than in substance—he indulges, with much circumlocution and superfluous apparatus, in a prolix and declamatory rambling about the generation of meteors and comets, drawn just as he was able to draw it from the books of the common run of philosophizers. There he puts forward things partly uncertain as if explored for certain, partly plainly false. Moreover, on astronomical matters—which he scarcely greeted from the threshold—he is not ashamed to hold forth pompously and to meddle in astrological ones, which enjoy nearly the same license in fictions as painting and poetry. And when at last he comes to the matter itself, he brings forward nothing better or fuller, as regards the observations, than in the preceding writing—although in the meantime about three months had elapsed, during which it would have been possible to be better instructed about this Star, whether from his own observations or from those of others.

—instructed by others' observations. But as for what he holds there (of which he had also made mention in his earlier pages): that this Star, after the manner of the epicycles, in imitation of Jupiter—which at that time was approaching the perigee of its epicycle—had raised itself toward the higher region, and on that account had shifted its position somewhat forward—this is wholly false, nor in any way consonant with the Star's own appearances, if these are carefully attended to.

Furthermore, he there drew a figure in the likeness of a quadrant, and takes its uppermost circumference for the concave of the lunar orb, which, after the Ptolemaic manner, he removes at least 33 Earth-semidiameters; and just below this he distinguishes, with equal intervals, the three regions of the air together with the uppermost sphere of fire (following Aristotle [Aristoteles]); and he deliberately places the Star in the uppermost portion of the air, next to the fiery element (if any such there were)—and that at a distance of 30 Earth-semidiameters, or 2579 miles (as he reckons), and 2905 paces (such precision, or rather futility!). And he carries out everything unskillfully and without sound reasons, and conducts his demonstrations by mere delineation of a sort, and administers the same incompetently and confusedly, clinging to the manner of painters; and—worse still—he carries the matter through wretchedly and ineptly. Which is evident from this very point: although, against the parallax that could be elicited from his own observations—which raised the Star to at least 185

semidiameters from the Earth's center—he does not scruple to make its remoteness only 30 semidiameters. And thus, by a certain gross ignorance, in his painted and fictitious delineation, and through the unskilled measurement deduced from it, he brings the Star six times closer to the Earth than his own data [δεδομένα, dedomena, "the things given"] allowed—which surely convicts of excessive ignorance of this Art a man who boasts of having been devoted to it for 20 years. Certainly, if the distance of this phenomenon from the Earth's center had been no greater than 30 of those same semidiameters, at its highest altitude, when it was nearest the zenith, it would have hinted at a parallax of m. 21 [21 minutes]; and at its lowest descent it would have rendered the same as p. 1 / 46 [1 degree 46 minutes], so that the composite parallax of the two altitudes would be p. 2 / 7 [2 degrees 7 minutes]. Yet Buschius's observations supply at least 20 minutes for this. If, therefore, this Star had to be as low as he intends, the altitudes would have had to stand otherwise, both near the zenith and at the horizon—that is, here at p. 21 m. 11 [21 degrees 11 minutes], there at p. 79 m. / 2 [79 degrees 2 minutes]. And these, in the latitude of the place at p. 51 / 10 [51 degrees 10 minutes], would have to be assumed as he presupposed. And in this way the observations would more readily square with the sublunary position that he makes for it—even with a gross one—so that the false might agree with the false, just as the true is always analogous to the true.

He further reports that on 12 December of the year 1572 he saw this Star in its greatest brightness, at which alone it could ever be observed—which in reality could not be. For in November it was still seen to be somewhat larger, as is clear from what was set forth in the third Chapter. Moreover, he then attributes to it a marvelous shape, by which it darted swords and rays—I know not what—into definite directions, contrary to custom, with a spectacle (as he will have it) horrifying. And this he supposes to have befallen it because of the trine aspect of Jupiter [♃] and Mercury [☿] celebrated on that night. Here he follows the Alphonsine calculation, which the Ephemerides of Leovitius [Leovitius] present—a calculation far too erroneous in itself.

For when, in accordance with Copernicus's [Copernicus] somewhat truer figures, that trine aspect of Jupiter [♃] and Mercury [☿] occurred four days earlier (granted that on both reckonings a deviation from the heaven itself may be admitted)—and what, I ask, would the trine aspect of Jupiter [♃] and Mercury [☿] do here? If this Star, so easily, had felt some variety from the configuration of the planets, how many and how great metamorphoses would it have undergone throughout its whole duration, in so manifold a coming-together of those same planets and in their mutual radiation upon one another? Therefore, if any such

thing had then been discerned around the Star at that time, it would have arisen out of fantasy, through the vapors and the quality of the intervening air, and would falsely have been attributed to the Star itself—whose pure and uncontaminated form perpetually, as long as it lasted, shone forth from heaven like that of the genuine stars, and felt no change except in color and in the diminution of its magnitude, until it ceased to be. Just as before, while we examined his first writing, we testified to the same, asserting something similar.

But when, like everything else, he sets about measuring the Star's visible diameter shortly afterward—and just as ineptly—he makes its apparent semidiameter m. 44 [44 minutes], so that the whole is g. 1 m. 28 [1 degree 28 minutes]. And in this way he makes the Star almost three times larger than the Sun itself, and presumes that it would have rendered all other men nearly as blind as Venus's star [Venus], had they gazed upon it when it was at its greatest. If it had shone with such size, with the light it was endowed with, this Star would surely have shone much more brightly than the Moon (even at full), would have been able to disperse the darkness at nighttime, and no night would have existed while this Star stood in the Arctic region of the world, where it never set. And how does so monstrous a diameter of the Star agree with that magnitude which he had earlier and afterward asserted Jupiter's star [♃] to have—and rightly so—as somewhat more perceptible? So that, on this account, it ought not at all to be a wonder that, in predetermining the Star's distance from the Earth, he admits things that conflict with his own observations—since in the apparent magnitude itself he is contrary to himself, so grossly and ineptly. For these things lie open most easily to all eyes of the sun. But that subtler unraveling of the parallaxes was something scarcely open even to those moderately versed in astronomy, much less to painters.

From this excessively enormous and excessive magnitude, appearing as p. 1 / 28 [1 degree 28 minutes], and from a distance from the Earth that was no less false—which (as I said) he makes 30 semidiameters—he assumes, imposing upon himself and others: that the Star's true diameter was $563\frac{3}{4}$ German miles, and on his own mechanical delineations and inept measurements he builds in vain. Here indeed, by these data, he strayed by four miles from the just dimension. But from the Star's true size—which it possessed in the celestial world among the rest of the fixed stars, and by which it surpassed beyond all measure that which several hundred times over outdid the whole mass of the Earth (as the seventh Chapter set forth)—he establishes scarcely an eighteenth part of it, if everything is reckoned by cubic proportion.

But just as this Painter Buschius deviates intolerably in defining the Star's position in the diameter of the world, so too in defining its magnitude, both as seen and as it truly was—so likewise, with the fictions of the pictorial art, he abuses too licentiously in an astronomical matter...

he abuses it too licentiously: for when he says that on the day of 20 February he noticed that this new Star had receded 2 degrees and 20 minutes from the little star of Cassiopeia [Cassiopea], to which it was near, toward the Arctic pole, he infers from this that it had some motion of its own. And so, deceived by his own false and frivolous misapprehensions, he asserted this without any verified experience. For that this Star remained wholly unmoved in the same place of the heaven throughout the whole time of its duration, and departed not at all hence in any direction, and always kept perpetually the same interval from this star of Cassiopeia [Cassiopea]—from which it stood apart by at least one and a half degrees of distance (so far from its having shifted $2\frac{1}{3}$ degrees away)—is so certain, and free of all doubt, and confirmed by the testimony of very many who attentively considered its place, that it needs no refutation.

Finally, he reviews the comets observed by Apianus [Apian], and the things that came to pass after their appearance in certain following years in this lower and terrestrial world; and he attributes these to them as if to their authors and signifiers (though I would not truly call them so). Afterward he attaches more nonsense of the prophesying kind, drawn from the portent of this Star, which—out of his own Pictorial head, so to speak—he depicts, smearing on colors at will with his brushes, as if. Perhaps he was afraid that, having spewed out such trifles in his earlier writing to the point of nausea, he had not done enough in his task of inventing and feigning, and so left behind some fables there to be patched up. Nor should it seem strange that, accustomed to forming pictures at his pleasure in ways that do not correspond to truth, and thus caressing and deceiving the eyes with an empty figure, he should be found, in astrological matters too, fertile in excogitating the vanities to which others are otherwise prone, so easy and abundant—so that he confirms by a double example that worn-out verse which, in jest, asserts that it is permitted "to lie for astrologers, painters, and poets" [*Mentiri astrologis, pictoribus atque poëtis*].

But since nearly everything published by Buschius about this Star—both in his writing as it is astronomical and as it is astrological—departs beyond all measure from the truth of the matter, we will pardon these aberrations of his, since the inexperience of both Arts excuses him; nor will we linger any further in refuting them (since in themselves they are too slight and incoherent). This much at least I

will indicate, by way of a colophon: that Nolthius [Nolthius] and Buschius [Georg Busch], the two of whom we have just now been discussing, went astray about this Star each in his own different way. The former, in that he badly corrupted his observations—especially as regards the altitude, which were not so very incongruous—and superimposed upon them things at variance with them; the latter, in that, while he used his observations well enough as to the computation, nevertheless assumed them to be less suitable than they were. Deceived therefore by a different mode of deviation, both striking hard upon one and the same rock of error, they suffered shipwreck of the truth: in that they incompetently pronounced this Star to be a participant of sublunary nature, and some burning meteor. Granted that Buschius, raising it higher toward the Moon's sphere, [less than the other]...

and so he appears to have strayed off in another direction. Yet this deserves only a modest excuse, since he wandered no differently than the star itself did—through the spheres of all the planets, indeed through the whole heaven.

Let us now turn our attention to the pen of Graminaeus [Theodor Graminaeus], who, with even greater license—building upon a false and worthless foundation—abused his subject impudently and went astray in two ways at once. He sinned excessively, first, in that he produced no observations at all, whether good or bad; and then, in that he wholly neglected the demonstrations and the calculation, whether competently or incompetently carried out. What is more, relying on certain extraneous assumptions that contribute nothing here and are frivolous in themselves, he polluted his work with still greater ineptitude and vanity. And, carried away by reckless impulse, he raved so wildly that he laid bare his own shameless and intemperate passions—coupled with equal incompetence—rather than the properties and accidents of this star. We shall therefore review what he published, and, since it does not merit any laborious treatment, subject it to a brief examination.

THEODORVS GRAMINAEVS [Theodor Graminaeus]

Under the pretext of dealing with this star, Theodor Graminaeus—who at that time served as professor of mathematics at Cologne [Coloniae Agrippinae, Cologne]—issued to the public a long-winded Commentary (or rather a fiction). In it he offers almost nothing that bears on the astronomical investigation of this star. Instead, with mere irrelevancies that contribute nothing to the matter itself, he fouls his pages by filling them uselessly—so that what Palingenius writes of poets, namely that they string together fables in their verses at least with some elegance, applies aptly to his idle chatter:

Their words glitter with trappings, but they hold no marrow within; only an outward image is on display, and the painting is shallow. But whoever reads such things, what has he learned in the end, what does he know but dreams and trifles?

Indeed, who would not rightly say the same of this uncultivated and inept writing of Graminaeus—except that poets, in setting forth their inventions, are themselves more excusable, since beneath these fables they generally conceal something true and of solid doctrine? But this man, beneath the nonsense he recounts, has far less in reserve than the very frontispiece promises. His aim was to compose a declaration and exposition of this New Star, which he wrongly calls a comet. In place of that, he has rather patched together obscurity, entanglement, and deceptive impositions.

Moreover, in the dedicatory epistle to the most distinguished consuls and senators of the Republic of Cologne, he maintains that this star was a comet. From this it follows that not even

a genuine fixed star of the eighth sphere could have been reckoned [*Stella Fixa genuina Octauī Orbis*]—as if for that reason nothing remained but that it should be called a comet. And although he rightly asserts that there sometimes occur comets that are not tailed, he nonetheless does not find it necessary to include this one in their number. For he supposes that it was not entirely without a tail, but that, while the Sun was traversing the more southern signs ♏ ♐ & ♑ [Scorpio, Sagittarius, and Capricorn], its tail, on the opposite side, was turned upward away from our view into the upper regions—something that could not happen at all.

For not even then, when around the beginning of Scorpio the Sun was set opposite to the star with respect to longitude, could the tail (if any had existed)—which ought to have been produced by the Sun, and therefore extended diametrically away from it into the opposite quarter—have pointed so far upward as to be invisible to us. For this star had a latitude of about 54 degrees [Latitud. 54 *fermè* Grad.], by which it was deflected from the point opposite the Sun. Hence, if it had displayed any tail, it would have presented it to us to be seen aslant as well. In vain, therefore, does he conjecture that, when the Sun came to the northern signs, the signs of its beard would appear—a thing in which he was wholly mistaken. Yet, to have a way out, he excuses the fading of the tail by appeal to the star's diminishing brightness. In vain, too, does he allege that this star afterward presented a different shape near the horizon, attributing this to its fiery nature—whereas this, whenever it seemed to occur, happened by accident through interposed terrestrial exhalations, as we have explained elsewhere.

In the work itself, however, he sets forth nothing in the middle that concerns the star—as regards its position relative to the zodiac and the equator, much less the parallax that needed to be worked out. Nor does he, in so renowned an academy, properly fulfill the role of the mathematicians. Instead he invents some old wives' fables out of the figures that antiquity used to attach to the stars, and, with a blind disposition of mind, abuses them wrongly—and as badly as maliciously.

He next enumerates a great many comets that shone in earlier times, and arbitrarily assigns to them outcomes drawn from events that happened afterward. Indeed, he even summons the poets here, and the tales of marvels; he heaps together passages from the Scriptures themselves; he adds the celestial circles and spheres, and almost all the northern figures of the sky depicted there, and expounds them fancifully according to his own imagination (in order, I suppose, that the Cologne printers, who had used the same illustrations in the *Phaenomena* of Aratus, should not let their woodcuts stand idle). Indeed, he did not think even Orion should be omitted, although it lies near the equator, toward the south, far from the zodiac. He also repeats the old prophecies of Abbot Joachim [Joachim of Fiore] and of Lichtenberger, and interprets them spitefully against Luther [Martin Luther] and the followers of his doctrine. In what regard these things are to be held, it is not relevant to discuss here. Nor did he restrain himself from dragging in Luther's nativity—the casting of the heavens at his birth—long ago set forth by Gaurico [Luca Gaurico] and Cardano [Girolamo Cardano] not on the basis of sound judgment but rather of reckless astrological prejudice, although it has nothing to do with the matter. Here I cannot pass over in silence how inconsiderately and

erroneously both of them—Gaurico as much as Cardano—designated the time of Luther's birth, together with the celestial scheme built upon it. For he was born in the year 1483, on the 10th of November, at one o'clock before the middle of the following night, as the *Calendarium* of Eber [Paul Eber] has it—even though Gaurico assigns his birth to a full year later. And although Cardano holds a more correct view regarding the year, nevertheless, since he, like the other, makes the 22nd of October his birthday—both anticipating the date by nineteen days—he went astray. I say nothing of the fact that Gaurico places it one hour after midday, while the other has it ten hours later. From these points it is sufficiently clear how variously the position of the heavens—as drawn up by Gaurico and by Cardano—departs from the genuine time at which Luther came into the light.

That the time which Eber indicates is consistent with the truth is probable, since he lived with Luther and was an intimate friend. And that the day—about which

both of them erred so greatly—was rather the eve of Saint Martin's day, is likewise plausible: for in former times parents used to name their children after those festival days of the saints, that is, of the men, whom they held in esteem. On this account it becomes consistent that he was born on the 10th of November, the day immediately preceding Saint Martin's, and not on the 22nd of October, as they falsely suppose. It is therefore clear how ineptly and imprudently—or rather, to speak more truly, impudently—Luther's nativity (which by no means was such as these astrologasters whom he cites represent it) is brought forward by these men, so that he [Graminaeus] might vent his own venom and mix it in; and so, while inventing such things himself along with others, he holds himself up to ridicule among the intelligent.

Of the same kind, too, is this: that he did not neglect to render into German the words of Gaurico, by which Gaurico pronounces that Luther died from the direction of the ascendant to the conjunction of Mars [♂]—paying no heed, in his astrological soothsaying arrogance, to the fact that the direction of the ascendant to the body of Mars, in the position Gaurico assigns it, reaches, according to the celestial system, to about the 51st year of age. For there Mars stands at 21° ♐ [Capricorn], and is in the last degree of ♉ [Taurus]. Therefore, at an altitude of the pole of 51 degrees, they would pass at least 51 parts of the equator before Mars met the horizon—which by the astrologers' reckoning makes up the same number of years. But since Luther survived twelve years longer, these excellent prophets—Gaurico as much as the one who cites him, Graminaeus—have proved themselves in this matter; or, what is truer, they have betrayed an abuse of the astrological art coupled with equal malevolence and emptiness of judgment.

All of which I wished to point out here, at least in passing, even though in themselves they contribute nothing to the present business—so that it might be plain how unjustly and maliciously Graminaeus, even on a frivolous occasion of no moment, assails and carps at Luther and his fellow believers. For I do not say these things because I wish to interpose a judgment about religious controversies. Let him judge them who knows how to distinguish the true from the false, and who alone knows how to search the hearts of all and to decide everything without prejudice. But it would be too tedious to pursue all the points in which

this strawy author—Graminaeus, I meant to say—publishes his insipid censure, perverse and at odds with others who think differently from him and his followers in matters of religion, and rages drunkenly against them. Indeed, he does not scruple to attack not only particular persons but whole regions together with their inhabitants, with a kind of preconceived venom of mind. Saxony,

namely, and the rest of northern Germany he likens to bears and dragons assailing the Catholic Church; he makes Cassiopeia, seated in her chair, a figure of the Roman Church; and he heaps up many other trifles of this sort—peddling smoke instead of the matter itself, without honest judgment, indeed with great prejudice and an impotent passion of mind—piling them up just as he pleases. To repeat all this point by point both wearies and shames me. For with no restraint he spews out in a heap whatever came into his mouth, and whatever hatred and a depraved disposition, and a perverse censure of things, suggested to him. Indeed, he rashly and ignorantly misuses Cabalistic indications that savor of something deeper than that man could perhaps ever have sniffed out.

It is truly ridiculous (if not downright shameful) that, although he approves the papal doctrine, he nonetheless compares the Roman Church to Cassiopeia and to her chair as to the papal throne—when Cassiopeia, on account of her pride and arrogance and her contempt of the gods above, ascends in such a posture, with her head down and her feet up, that she is said by the attributed figure to sit upon a stool and to hold a reed in her hand, and is depicted as a naked and shameless figure. If these things are to be expounded hieroglyphically, the question is how far they square with the Roman Church which he defends—certainly they do not commend it with any great honor on this account. Hence, had he kept silent, he might perhaps have consulted more rightly for the papal hierarchy.

But I do not wish to unravel everything that he scrapes together, with prejudiced and blind passion, about religious controversies—scattered here and there—in order to extol and defend the party he follows, while attacking and detesting others, especially those who call themselves Evangelicals, and pronouncing them enemies of the true Church and profane men. For the most part he plays and trifles with the cabalistic figures and forms that antiquity assigned to certain stars; and from these he builds up I-know-not-what mysteries and prophecies by an empty imagination. For even though a true Cabala and Magic, if they are handled without abuse and without offense to God and his creatures, do disclose and reveal—through images, figures, and signs—many things otherwise abstruse, nevertheless these images of the celestial constellations, which gave birth to such empty speculations in Graminaeus, have no connection with the Church, whether true or false, or with the administration of the present monarchy in which we now live. For there were certain pagan philosophers who had either no knowledge of God, or his Church, or at any rate a very obscure one, and who, in the manner of a feigned and ordered arrangement, distributed the stars into definite shapes of living creatures and other things, so that they might be more readily distinguished and lie open to knowledge. And if there was anything of

hidden powers present there in accordance with their cunning shapes, they wished it to be magically represented,

they failed to consider the Church of God, or the heresies and controversies that would arise under that Church — since none of this could possibly have occurred to those people, or even have entered their minds. And yet, to make his account plausible, Graminaeus [Theodor Graminaeus] impudently invents the claim that the Bears and Dragons and other monstrous shapes attributed to the stars circling about the North Pole stand for the enemies and persecutors of the Church who would arise from the northern regions of the earth — and that it was not the nations outside the Church, ignorant of divine matters, who first assigned these images to the stars, but rather the Patriarchs, from whom they passed down in succession to those nations. He fails to consider that nearly all the constellations marked out by definite figures took their origin from the men and deeds of the pagans, and above all from the fabulous tales of the Greeks. I do not, of course, deny that knowledge of astronomy passed from the Patriarchs to the Phoenicians and Egyptians, and from them onward to the Greeks. But that those Patriarchs sprinkled the heavens with such figures and fictions I consider in no way credible — especially since the Jews, descended from them, were beyond all other peoples expressly commanded by God to abhor images and pictures. So far were they from being willing to allow such things even in earthly and political affairs, let alone to fill and defile the whole heaven with them.

A thoroughly reliable and trustworthy witness to this can be Josephus [Flavius Josephus], the historian of Jewish antiquities, who nowhere records that they admitted any images or likenesses whatsoever, except where they obstinately broke the law. Indeed, they would not even allow Caesar's insignia and the painted Eagle to be brought into Jerusalem: they chose rather to suffer anything, and even to endure death. How, then, could the ancient Patriarchs — far more religious than those Jews living in Jerusalem in Josephus's day, and far more observant of the divine will — have painted fictions and fabulous images upon the heavens, or rather fashioned them onto it in pagan fashion? But let these notions pass: they are unworthy to be recalled, and to be refuted at greater length.

When Graminaeus discusses the cause and generation of comets, he reviews the opinions of certain ancients, and subscribes to that of Aristotle [Aristotle] — which was very nearly the most false of all. Nor is it any wonder that a man so enslaved to trifles and fictions (led, as it were, by a certain bent of nature) should lend a most ready ear to such things.

In the same place he also mentions the Paracelsian view concerning the higher household gods [Penates superi], which, however, he corrupts by understanding it less than correctly: he supposes that Paracelsus [Paracelsus] meant the planets by these "higher household gods," whereas no planets are to be found there — a notion utterly foreign to Paracelsus's meaning. But there will be occasion to discuss this matter elsewhere, in a more suitable place.

Concerning the effects of this star, he holds that it portends almost nothing other than what is commonly imputed to comets. Yet in the meantime, because from the outset it displayed a splendid, lovely, and brilliant form, he reckons it as a sign of some good omen. And although he has elsewhere said several times that comets are ill-omened and harbingers of evils, here he nonetheless wishes certain favorable and good outcomes to be foretold by it. He does so especially under this pretext: since this star shone with so gentle a countenance in the Throne of Cassiopeia [Cassiopeia], he flatteringly promises increase, prosperous successes, and the trampling-down and devastation of enemies, to the Roman See and its adherents — and indeed to himself and his fellow sectaries.

Now, since these things are put forward on astrological conjectures — even if somewhat plausibly, according to the apotelesmata [astrological prognostications] of the Art — yet they are fetched from too far afield and applied forcibly. I therefore prefer not to involve myself in them; and I pass over, without further comment, the rest of what Graminaeus puts forward, which contains almost nothing solid or properly belonging to the astronomical or even the astrological treatment of this star.

It would certainly have been fitting for Graminaeus, a Professor of Mathematics at the famous and venerable University of Cologne [Universität zu Köln], to have brought forward something about this star that tasted of the learned science and practice of mathematics as well — and to have exposed the errors of the unskilled, rather than augmenting and confirming them — and to have published it, while leaving aside theological disputes and cabalistic prophecies for others. But since the world teems with the variety and vanity of foolish opinions, he was perhaps afraid that he would not be reckoned a true Cosmopolitan unless, along with everyone else, he indulged opinions wrapped in masks rather than sound reason. Perhaps too he was hoping, by this means, to win the applause not so much of the unskilled crowd as of certain others — assuming for himself some erudition or other, I know not what, in mere outward show. For more and more men of this sort are to be found even in the universities, where the Liberal Disciplines ought to be treated seriously and from the foundations (which is a

thing to be lamented). But how the untrained, and those little instructed in these Arts, may judge of so lofty a matter concerns us no more than if the blind, or men with bleary, ailing eyes, were to pronounce on colors they cannot readily distinguish.

I have chosen to append these things only with regard to Graminaeus's inept speculations and the clouds of fantasies that obscure this star rather than illuminate it. For if everything that he has heaped together about this matter, verbosely and confusedly, were to be examined and refuted, much paper and time would be uselessly consumed: the labor spent in refuting it would be little better than the labor he spent in writing it.

I shall now run briefly over certain others who have handled the affair of this star astrologastrically [in the manner of bungling astrologers] in their annual Diaries, treating them in passing, since they do not deserve a laborious investigation.

A summary examination of certain others who held this star to be a comet, and who judged of it incompetently

It is irksome to call to the bar, one by one, the opinions of all those who everywhere pronounced an absurd and incongruous verdict on this star — and who, for the most part, year after year shamelessly bespattered both this Art and themselves with no slight stain through their most trifling astrological prognostications. It will therefore suffice to remark, in summary, upon what a few of them have put forward.

Adam Ursinus [Adam Ursinus] of Nuremberg, in his Prognostication for the year 1574, according to the license of the astrologasters — which they hold in common with painters and poets — appended an exposition of this star (which he too imprudently calls a comet). And he says rightly that it could be seen throughout all of Europe and Asia — indeed throughout the whole terrestrial globe, except for a small portion of it near the Antarctic Pole. He would have put it better still if he had said this not only of the star but also of all comets, which rise upon the horizons of the terrestrial globe and tower above by the universal motion. From this very fact one may rightly reason that they do not exist in the sublunary air.

He adduces no astronomical observations — at least he speaks of the rhomboidal figure that the star formed with the three more notable stars of Cassiopeia, which was plainly visible to the eye and to everyone unskilled in this Art. Yet he does not pronounce amiss when he says that the Philosophers and Historians of

preceding ages did not record the appearances of comets accurately enough, and that in their writings scarcely anything similar to this star is to be found.

Concerning the color of the star, he rightly states that around the start it presented a clear and bright appearance. But where he reports that it mingled in a certain pallor, which after the winter solstice passed into a dusky redness, this did not fit it: for it then displayed no pallor at all. And although in the course of time, especially as the following spring drew on, it took on a whitish color tinged with a certain yellow, it nonetheless did not present an exquisite redness — much less this dusky kind — but rather forced upon the eyes a sort of Martian and fiery hue, a yellowness: such as is the color of the star the Romans called Palilicium [Aldebaran]. As we have likewise indicated earlier in its proper place.

He truly affirms that its visible magnitude surpassed all the stars, both the Wandering and the Fixed, with Venus alone excepted. But where he reasons that it was a comet — in accordance with the Doctrines of the Physicists, lest perhaps it should overturn them — and where, against the common view that called it a New Star, he asserts this, he puts forward in this respect a sentence that is ill-considered and less than fitting. For although it may not undeservedly be said, "he who hangs upon the lips of the crowd is deceived and deceives," yet, if he and others who [made it] a comet out of this unusual star

brought it about without just reasons, when they would rather have agreed with the common and unlearned people than with the Physicists preoccupied by their prejudgments, and would truly have confessed that a New Star had shone forth — then assuredly they erred less far from the truth than the matter actually was. And indeed not a few other things are perceived far more rightly by the common Folk, by Rustics and Sailors and other untrained people, than by most of those who profess some knowledge or other of natural things out of the books of the Philosophers commonly approved, and who declaim the same publicly in the Schools. The authority of famous Men and one's own prejudice, without any settled Experience, bewitches people for the most part. Would that this at least held good in Philosophical matters among most people, and not in one matter alone — or rather much more so — in truer and real Theology, which is not to be uttered in mere words and in subtle, useless theoretical disputations (as is wont to happen), but is to be carried out in practice alone, and which turns men's minds away from God and heals their vices. For not in vain was it said by the Lord: "I give thanks to thee, Father, because thou hast hidden these things from the Wise and Prudent, and hast revealed them to the Little Ones. Yea, Father, because so it has pleased thee" [Matthew 11:25–26]. And Paul speaks to the same

effect: "Few are Wise according to the Flesh, few Powerful, few Noble" [1 Corinthians 1:26]. But these things lie outside the subject proposed.

Next he reviews the twelve species of comets put forward by Pliny [Pliny the Elder], and reports this star among those that are called *Chrysos* or golden, and are orbicular in shape. This too is done without just occasion. For nothing — whether with this comet-species or with any other — did this star have in common, if everything were thoroughly examined, except that it varied in color and magnitude and at length ceased to exist: as was likewise said earlier.

Furthermore, that he should assign the star's place to the sixth degree of [Cassiopeia], and report it so — that is not very far off, except that a whole degree is nearly lacking. He does not add its latitude, and for that reason he can rightly and deservedly be charged with not having fully expressed its position.

But where he says that, in the diurnal revolution about the Pole, it perpetually kept the same distance from the three stars of Cassiopeia, with which it formed a Rhombus — that is indeed true in itself, but it is contrary to his own assertion, since he makes it a comet: unless, together with the one ill-advised opinion of the Physicists hitherto received, he is willing to concede that comets are partakers of the ethereal World, and so can exist not only among the regions of the Planets but even in the deepest Eighth Sphere.

He puts the maximum altitude at 79 degrees, the minimum at 22. And this in too broad a fashion, neglecting the minutes. Yet from the revolution which about the

having worked out the elevation of the pole, he did not stray very far in his arcual diameter [arcuali Diametro]; he made it somewhat too large, by about half a degree. And had he added one further degree to the elevation of the pole, he would surely have recognized — even from this rather coarse investigation, once the observation had been properly carried out — that this star was by no means sublunary.

What he subsequently appends about the star's significations, after the manner of ordinary astrologers, I do not wish to discuss. I will note only this one thing, that at the end of his treatise he cites a certain aphorism of Cardano [Cardani; Girolamo Cardano] which runs as follows: *Albumasar [Albumasar; Abū Ma'shar] said that the comet was seen above Venus; therefore it is not in the elemental region, contrary to the Philosopher.* This passage, I say, was not improperly brought forward by him at this point, and he rightly advises that the pronouncements of the most ancient astronomers of this kind ought to be weighed, and more carefully compared with the phenomenon. And had he

himself also done this, he would surely not have assigned this star to the order of comets. Nevertheless, if he holds that this opinion of Albumasar prevails by the authority of Aristotle [Aristotelis], and supposes that all comets are ethereal, and that this New Star too chose for itself a seat in the celestial world — which, however, he does not openly admit — then he would in some measure deserve forgiveness for having improperly called it a comet.

Andreas Rosa [Andreas Rosa] of Schweinfurt [Suingfurdensis], Doctor of Medicine, in his own Astrological Prognostication for the same year 1574, likewise makes mention of this star. But he barely touches with a fingertip on what pertains to its astronomical consideration. He says only that it was seen, on first appearance, both bright and conspicuous. And not without cause he doubts whether it should be placed among the kinds of comets that Pliny [Plinius; Pliny the Elder] catalogues, and he prefers to think with the common people about it, and to call it a New Star. In this respect he is less deceived than those who, on the basis of the arguments of the philosophers, maintained against what the very sense of his own eyes showed him that it had been a comet.

Afterward he briefly wove together an astrological prophecy concerning its effects, which I have no desire to pursue at length. This much only I will add. If what he there seems to assert is true — namely, that miracles of this kind come forth from heaven roughly every two thousand years, and that they agree, divided into three parts, with the ages of the World according to the saying of the Talmudic Elias [Eliæ Thalmudici] — then it would indeed be plausible that this Star too portends the completion of the third Period, and the consummation of the visible World (which is also what he means to suggest). But on what grounds will he prove that, with the two prior millennia of years nearly complete, before the Universal Flood [Diluvium Vniuersale] covers the face of the Earth and swallows up all living things, with few excepted, a prodigy of this kind — such as this New Star displayed overhead — was shown?

And what of the fact that, at the departure of the Israelites from Egypt into the Land promised to their Fathers, a column of fire went before them by night in the desert? He strives to liken this Star to that — and to place it about another two thousand years ago (which, however, does not agree with the time of their migration, for it occurred about the midpoint of the interval, between the Flood and the birth of Christ, some eight hundred years having just elapsed since that very flood). This attempt is utterly devoid of all Reason and Truth. For the column that opened the way through the desert for the Israelites was discerned in the air itself, not far from the surface of the Earth — for otherwise it could not have

indicated the route they had to travel, or the various turnings and windings, and where they ought to halt — since things observed on high in heaven have no bearing upon so narrow a span of space on Earth.

In the same way, when he equates this New Star with the Star that, having set out further from the East, brought the Magi to the place where the newly born King of the Jews was, where they came to worship him, and which pointed out to them where they were to proceed and into what house they were to enter — he is no less deceived. For granting that this occurred about four thousand years roughly complete from the beginning of the World, and that the torch which went before the Magi obtains the appellation of "Star" in the Evangelist Matthew [Mattheum Euangelistam], nevertheless that very Star had nothing in common with this one of ours. For that one was carried through the air, near the Earth — otherwise it could not have marked out the particular house in which the infant Christ was. Moreover, this vision was, by a certain peculiar dispensation, divinely shown to the Magi alone, who had set out from the East; we do not read that it was visible to the Jews or to other men besides these, who were skilled in a more genuine kind of magic. So both for these reasons and for others adduced elsewhere, that Star which guided the Magi cannot be compared with this one shown to our age from heaven.

Nor again is it quite fitting that, because he says the Star of the Magi was seen in the East, as though near the beginnings of the Earth, while this one appeared near the end of the World, close to the Arctic Pole [Polum Arcticum] — and therefore, just as that one was the beginning of salvation, so this one foreshadows the world's destruction. But what will make a beginning on the round globe of the Earth, and what an end? The Magi are said to have set out from the East because their Region was situated toward the Rising with respect to Judaea — not because there is any place on Earth from which East can, of itself and without reference to other Horizons, be predefined. So too the Earth has no end whatever under the Poles, whether Arctic or Antarctic, since it is there equally round as everywhere else throughout its whole circumference. Indeed, this Star too was removed from the Arctic Pole by very nearly 28 degrees, through almost a twelfth part of the terrestrial circuit — if the places of the Earth over which it stood vertical be duly compared with the point set beneath the Pole itself.

Non

I will not, however, deny that this Star signified something great and new. But whether it signified the destruction of the World — who, I ask, will make this clear to us?

Furthermore, he holds that no star of this kind was ever seen before, and that this can be proved from the Histories; and this I would readily grant him. But where he detracts somewhat from Pliny, in reporting that Hipparchus [Hipparchum; Hipparchus] saw a New Star in his own age, I judge that he is not to be approved. For why would Pliny have invented such a thing about so great a craftsman, unless he had read something of the sort in his writings — Pliny being, as he was, a tireless surveyor of the monuments of the ancients? Nor, moreover, did that star which Pliny mentions agree with this one in every respect. For that one was moving, whereas this one stood fixed and motionless throughout. But I cease to linger any longer over the prophecies and opinions of this Rosa, which are not redolent of the accurate and proper consideration owed to the Star with regard to its appearances and determinations.

There have also been still others (whom I will include all together in the place of that third fabricator of Calendars) who held this Star to be a comet, and who, without any reason or established observation, assigned to it sublunary seats in the elemental air. Thus some put it at 19 [semidiameters], some at 15; indeed there are even found those who thought it stood at least 12 Earth-semidiameters [Terræ Semid.] distant — being ignorant that, at a remove of 19 semidiameters, it would have exhibited a parallax of very nearly 3 degrees when it was near the Horizon; and at 15 semidiameters, the same parallax of 4 degrees; while at 12 semidiameters it would have hinted at very nearly 5 degrees. And surely, by the change and diversity of place through parallax, this could have been detected by the eyes alone, without any instrument, even by those unskilled in this Art.

Indeed, a certain impudent impostor was not ashamed to confine its magnitude, beyond all measure, within 750 miles — and he claimed that the Star first arose by the Neck of Cassiopeia [Collo Cassiopeæ], and thence proceeded to her right shoulder; and that between the second and the twenty-first of its [days?] it traversed, in an interval of 53 days, 19 [numeral: ?] /6 // 1 /// [as printed]. O most empty trifler and most worthless splitter of scruples! Just as, under the pretext of Medicine and Chemistry [Chymiæ] and other Arts and Languages (of which, however, he was utterly ignorant) which he boasted of, he made it his business to impose upon the unwary and to drain them of their money — practicing it splendidly, if anyone ever did, and assiduously plying that well-worn maxim *the World wishes to be deceived* [Mundus vult decipi] — so too he did not shrink from mocking the heavenly things, and from defiling them, so far as in him lay, with his frauds and lies. For who ever beheld this New Star beside the Neck of Cassiopeia, from which it was perpetually distant by ten degrees? Who marked any motion in it from a sure Observation,

noted? And who, I ask, could discern that motion (if there were any) by any diligence — not merely within first scruples [minutes], but also within Seconds and Thirds, so much so that not even a single one of the thirds should be passed over — by anyone, however diligent a scrutinizer of celestial things, even one using the greatest and most exquisite Instruments, let alone by this deceiver, wholly unskilled in astronomical exercises? Among the common folk, equally untrained in these matters as he himself was, he might perhaps persuade people of such things, so that, in their ignorance, they would marvel at those futile subtleties of his. But among those who understand, he will at least stir up laughter — and, at such shameless fraudulence, abomination.

Yet it ought to be no wonder that one who fled from his own homeland of Germany so craftily and ignominiously, and who perfidiously deceived an excellent Prince who had deserved most well of him — indeed, more than he was worthy of — should also inflict injury and fraud upon the heavenly things, which are not so easily noticed by just anyone. But let this Sycophant fare on — he who, if he has not on this account escaped the vengeance of the Deity and the punishments he deserved, in that, after first afflicting his Homeland with long and so many great impostures, he then withdrew himself elsewhere: *his own punishment follows the guilty man*. Let him therefore be done with, unworthy that much mention be made of him. And on that account I have judged that he ought not even to be named, especially since he is notorious enough on other grounds, for his manifold cunning, tricks, and frauds. And so much for this man.

If, besides, any others are found who, with so brazen a face, have prattled about this Star — things so discordant and so foreign to all Experience — such as were certain men who attributed to it a motion of staggering (truly staggering in their judgment and in their eyes) and I know not what other accidents, to which it was nevertheless never subject: to enumerate these one by one, and to expose and censure those men's exceedingly foolish errors, I do not consider worth the trouble. For perhaps, with regard to those who have seemed to merit at least some consideration, I shall be able to be charged by some with having lingered too much over them (since not all things please all men).

Therefore, having spent quite enough, and more than enough, upon those of whom I had a mind to speak, I now bring to an end the treatment of all of them together — the matters which I undertook to embrace in the tenth Chapter [Capite decimo]. I am confident that I have carried out my proposal to the best of my ability; and that I have pronounced nothing against any Author without due cause. For only for the sake of laying bare and defending the Truth inviolate have

I brought these things forward, with a certain Philosophical liberty — not so as presumptuously to disparage anyone's Reputation and Doctrine. Now therefore, with the sails opportunely furled, let me fix the Anchor in port.

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CONCLUSIO

In which the matters treated throughout this whole book are summarily recapitulated, and a number of things are indicated in general and briefly — both concerning the substance and essence of this new star, and also concerning its significations (which press upon these nearest years).

Therefore, prompted by the occasion of that wondrous star which in our own age first arose in the highest aether near Cassiopeia, and was there extinguished by degrees, I resolved to commit the matter to writing and to transmit it to posterity, so that some sure knowledge of so great a marvel might be obtained. By the grace of the same primary Author of Predestination — who granted both the favor and the successful outcome, and to whom I also acknowledge that I owe this very thing — these labors have at last been brought to the goal I longed for. I believe, moreover, that in all the matters I had set out from the beginning to propose and explain, nothing that could be of any use has been omitted. In each particular I have worked with such diligence to extract the kernel of the truth and to vindicate the matter itself from the contamination of errors, that for those who understand mathematics and weigh everything with sincere judgment, no room is left for hesitation or contradiction.

But in order that the views which Astronomy can bring to bear upon this strange and altogether astonishing star — both those of others who agree with us and those who dissent — might be investigated, and that this investigation might be carried through the more readily and the more exactly, I judged it advisable to set forth in the first part of this volume certain more general matters, laying foundations not only for the explanation of this star but for the whole science of Astronomy.

And so in the first two chapters I first of all dealt with those things which establish an accurate restoration of the Sun's course, corresponding precisely to the heavens itself — nor did I neglect its sister, the Moon —

— we have embraced. Next, undertaking the subtle and exact verification of the fixed stars, no fewer than eight hundred of them, we built upon the foundation

already laid beyond doubt: their positions agree to the hairsbreadth with the celestial arrangement, both in longitude and in latitude.

From Venus indeed — that friendly and brightly shining star, both as morning star and as evening star — we predetermined the limits of the fixed stars with respect to the equinoctial points, by a manifold examination corroborated and checked in the reverse direction as well. And by these means we superinduced, with precise measurement and registration, the arrangements of very many (as I said) of the wandering [recte: fixed, "inerrantium"] stars — indeed of the principal ones, and of all those that appear to us near the Zodiac. Thus, proceeding by stages to the stars of the asterism of Cassiopeia — which were chiefly required for the purpose at hand — we arrived at a complete rectification, analogous to the heavens itself.

Yet to carry these things out in the proper manner required greater study and labor — not to speak of expense — than anyone inexperienced in such matters could estimate. He would readily pronounce a harsh verdict on us, thinking that upon this single star, and that one not permanent but long since liable to dissolution, we had sweated with too laborious an effort, expounding it from the very foundations of the astronomical art, and that we had pursued these things with deeper inquiry than the subject deserved. Nevertheless, since some solid and true result concerning this unusual phenomenon — one that should hold good on every side, rightly and exactly, and be subject to no ambiguity or incoherence — had to be brought forth, the whole thing had necessarily to be built up upon a firm and immovable base, one that would nowhere give way but would stand solid in every part. And this could not be accomplished without the restoration of the Sun's course and of the fixed stars, to meet the requirements of the celestial appearances. Among fair-minded judges, therefore — those who more shrewdly grasp the depth of the undertaking — I shall without difficulty earn forgiveness on this point.

But if we have amassed anything in these matters somewhat more abundantly than this star, as regards its own proper attributes, required, this has been done because it is of benefit to the whole art at once, and because we strove, so far as in us lay, to vindicate that art from defects, insofar as the occasion here offered. On this account I hope to win the gratitude of those eager for this sublime science, rather than their disparagement.

Indeed, although this star, which it was chiefly my purpose to treat, was an extraneous thing — yet since, contrary to the customary laws of nature, it shone forth miraculously upon us in the very highest aether, in the manner of the

genuine stars, and stood there unmoved for more than a year, it certainly seemed worthy to be considered carefully and fundamentally, and to be expounded as regards all its circumstances; and the labor of doing so ought not to be undertaken sluggishly or perfunctorily.

[Margin: 13] Indeed we recognize that even Hipparchus, with strength more than Herculean, drew from the heavens the positions of the stars of the Eighth Sphere that lie distinctly open to the sight of all, and left them to us in a testament (as Pliny speaks of it) [Margin reference: Pliny], on the occasion of at least one new star beheld in his own age — for which the memory of so great a man deserves our thanks — while we, surveying the curved heavens, recognize the Sun and the wandering stars. Yet it is likely that this star of his could scarcely be compared to ours in magnitude and in the majesty of its bright light and its lasting duration. Nor indeed was it immovable. And although it shone forth without tail and without rays of hair — for otherwise, since the appearance of comets is well enough known and frequent, he would not have expressly called it a new star — it could nonetheless be likened to those phenomena which, without a spreading beard, are seen in the manner of faint stars and exercise some motion of their own (such as the one we beheld in the year 1585). But be that as it may: we in no way regret the labor undertaken in this part, so far as our strength, and as time and other occasions, allowed. And we did this not only with regard to this new star, but in order to place the rest of the stars shining everywhere throughout the heavens in their proper position and number,

— to be set down, and so that, from this, the very courses of the planets might be the more accurately measured out; and we are confident that no small assistance will thereby be brought.

For if our predecessors, in noting the motion of the Sun (not to speak of the Moon) and in expressing it correspondingly in numbers, and in rectifying the true positions of the fixed stars as regards their longitude and latitude, had applied the diligence and industry that were required, and had left us all things agreeing to the hairsbreadth with the heavens itself — then it would have been permissible to dispense with the labor we have exhausted in the first two chapters, and to proceed at once to the matters concerning the star itself, the description of which we undertook. But since up to now this has been accomplished by no one, I therefore judged it worth the effort to set forth first those matters concerning the Sun, the Moon, and the fixed stars (since our observations on these have not been published elsewhere before, such as it would have been convenient to cite here in the case of this star).

[Margin: 15] In the second part of the book, however (which is completed in five chapters), we have accurately and faithfully set forth, from our own observations, the matters properly pertaining to this star. There, after those things which could be discerned in this visual observation through their several circumstances had been indicated in a general way, together with their attendant details, I gave an account of the observations made on this star, along with the construction and use of the instruments by which they were taken — so that the diligence and certainty of those observations might more readily appear.

[Margin: 23] And thereupon I demonstrated geometrically, in manifold ways and with exact precision, the very position of the star with respect to the ecliptic and the equator, and reduced it to numbers. From there, turning to the unraveling of its parallax, I proved by clear and variously unanswerable reasonings that it admitted of no parallax at all, and that it was raised not only beyond the elemental region and the confines of the Moon, but beyond the revolutions and orbs of all the planets, into the very highest sphere of the fixed stars. Finally, [its] magnitude

measured out its true magnitude. My aim was to set up a comparison that would be carried through not only with respect to the Earth but also conveniently and more correctly with the other bodies of the heavens. So too the orders, sizes, and quantities of the planets and of the fixed stars, which they actually hold in the celestial world, I determined succinctly and all at once, in a somewhat different way than has been done by our predecessors, leaving none of this untouched. In this way I have dealt fully with the astronomical consideration of this star — so far as the observations properly available to me allowed — in the five chapters of the second part (as was said).

In the third division, finally, I compared the views and opinions of others — as many as I could obtain — on this matter, both with one another and with my own, and I tested them against the touchstone of truth [ad Lydium veritatis lapidem]. First I examined those who put forward a view very closely analogous to my own concerning the star's parallax [Stella Parallaxi], namely that it admitted no parallax at all. Next, those who attributed to it some diversity of aspect [aspect, i.e. parallax], though not so great that the star would thereby be made sublunary. In the third place, those who either established nothing solid about it mathematically, or brought forward claims plainly absurd and far removed from the truth — that is, that this star was not new, but was some old star augmented in brightness by an accidental cause. And likewise those who tried to expel it from the heavens altogether, and, drawing it down to a place

nearer the Moon, wrongly degraded it into the elementary air: all these opinions I have examined. [Margin: 10] [Margin: 20]

And so in these last three chapters I weighed on a just balance the pronouncements that others had made about this new star — some of them in agreement with the truth, others deviating from it more or less. My chief purpose in doing this was that the inner truth of this lofty matter, once the byways and seductive errors had been set aside, might lie more openly revealed and shine forth more clearly — not so that I might flatter anyone, or assent to him below his merit, if he happened to put forward and approve things that were correctly established;

nor, on the other hand, so that I might carp at and attack those who, straying from the mark, brought forward views off the point, or so that I might exalt their reputation. Rather, in all these matters I had only this in view: that the walls of truth should remain intact and unbreached in their own undamaged defenses, and that the battering-ram of the assailants — whether driven by ignorance, or by deliberate effort straining to make an assault and attack — should be repelled; and that whatever was erroneous and faulty should be exposed openly to view and discredited. [Margin: 5] For by this method the kernel of truth is more correctly brought into the open and more safely preserved, if not only those things that conduce to it are adduced, but also the things obstructing it and at variance with it are laid bare through their own delusions and removed. [Margin: 10]

Yet when I reflect on how empty the opinions of others have been about this star, and how varied a judgment they have pronounced concerning its place and distance from the Earth — even though, on account of the star's immobility and the fact that it stood perpetually above the horizon, this matter could most easily and far more readily have been made plain to a sure and infallible demonstration than is possible in the case of comets, which take on some motion — I begin to wonder less, not only that the motions of the heavenly bodies have not until now been worked out by us with the accuracy they deserve, [Margin: 15] but that in the whole of philosophy, and in theological controversies, questions so much at variance and so doubtful are raised. For if that which was most plainly set before the eye, and could be measured with suitable instruments and demonstrated geometrically without laborious difficulty, nonetheless suffered such a variety and discrepancy of judgments — how much more will those things that do not fall under the senses, and lie less open to human industry, or at least display some depth and perplexity, turn out obscure and insoluble, far from exact

knowledge and indubitable truth (which alone can be one only, like the center in a circle)? Hence so great a confusion of opinions in all the faculties, and concerning matters

not only physical but also theological and political — discordant in manifold ways — are stirred up in the disputes among men; so that it is scarcely granted to anyone to grasp, in each single case, a settled certainty that conforms to geometrical demonstrations [Geometricis Apodixibus] and against which no plausible contradiction can be raised, and to apprehend it firmly. O wretched minds of men, O blind hearts! In what darkness, amid what perils, is this life passed, whatever it may be?

Therefore, since everything that concerned the astronomical consideration of this unusual star — both what was in every way rightly conducted, and what laid bare the deviations of certain men — I have set forth fully and more than fully in this entire volume, there seem to remain two further questions: one physical, about the matter and generation of the star itself, the other astrological, about its effects and significations. To treat these expressly in the present work, and to pronounce anything fixed about them, I judge it more advisable not to deal at length or seriously — much less decisively — since they are not subject to the senses and to geometrical demonstration, and have premises at variance with the undefiled certainty of mathematicians, premises that are at best merely probable or wholly conjectural. Indeed, I had already made up my mind to pass over them entirely, and in the judgment of certain people this would be reckoned the better course. Nevertheless, since most people rather crave a physical and astrological exposition of this star, and are exceedingly anxious about these matters — especially about the latter — neglecting, or less thoroughly investigating, the knowledge that lies nearer to the truth, I shall therefore, for their sake too, [Margin: 12] put forward some remarks about these things according to my own estimation. Yet I do so with this protestation laid down beforehand: that they are by no means to come into comparison or be set on a par, as regards undoubted evidence of certainty, with the things that have been propounded by demonstration and beyond just objection in this whole foregoing elaboration of the preceding Book — but rather are

merely conjectural, and brought forward from probable likelihood. And so in setting these out I shall be rather brief, and shall not dwell on them at length (as I have said). For this very reason I have relegated them to this last conclusion of the whole Book, so that I might introduce mention of them only sparingly and in passing. [Margin: 6]

Concerning the matter, then, of this adventitious star — to state my own opinion first — I judge that it was wholly celestial, not differing from the matter of the rest of the stars; yet in this at least it admitted a difference, that it had not been exalted to so great a perfection and solid coagulation as exists in the perpetual stars. For this reason, too, it could not endure perpetually, as those stars do, but was made subject to dissolution with the passage of time. For out of any elementary matter this star could in no way have consisted, since such matter is not carried up into the highest Aether, [Margin: 15] nor could it obtain firm seats there. Add to this that this star, by its magnitude, surpassed from the outset more than three hundred times the bulk that the Earth and the seas together make up. What sublunary matter, then, would suffice for its formation?

But someone may say: from where was this celestial matter at hand for its composition? In the heaven itself, I reply, this matter was ready enough — no otherwise than the Earth and the seas, and the air, when at times they bring forth new spectacles, produce them out of their own womb and substance. For although the whole heaven is something most rarefied, and everywhere pervious to the motion of the heavenly bodies without any obstacle, it is nevertheless by no means utterly incorporeal (otherwise it would also be infinite and without place). The matter of the heaven itself, then — being most subtle, and pervious to our sight and to the circuits of the planets — was nonetheless able, when condensed and compacted into a single globe and illuminated by a light, if not its own, then at least the Sun's, to fashion this star. And since this matter, almost monstrous, that monstrous thing arose, it could not maintain the same persistence as the rest — just as new generations and monstrous births that arise from the elements do not last long.

And although, in my judgment, throughout the whole vastness of the celestial world there is an abundant supply of matter for the formation of some adventitious star, nowhere is that matter more plentiful or fuller than along the Milky Way [via Lactea]. I hold this to be a certain celestial substance, not differing from the matter of the rest of the stars, but diffused—spread out across certain regions, not gathered into a single distinct body as happens in the stars, but massed together. From this I conclude that the New Star [Nova] took its stand at the very edge of the Galaxy. Moreover, the New Star itself hinted, not obscurely, that it had been formed from the same substance of which the Galaxy itself is composed.

Indeed, even now a certain gap is to be seen in that very part of the Galaxy where this star held its seat. This gap, on winter nights especially—when the air is

thoroughly purged by clear weather and the northern cold, which thins out the vapors of the air and makes all the other stars present themselves brightly and twinklingly to the eye, and the Milky Way then appears more distinctly than at other times (provided this is done around the new moon, while the Moon is hidden, and provided the sight of even the smallest stars is not dulled)—this gap, of a size roughly equal to that of a half-full Moon, anyone may carefully and distinctly observe and examine, unless his eyesight lacks sharpness. I do not recall ever having noticed this gap there before this star appeared.

Nor do we read that any such thing was recorded by those who in antiquity charted the course and configuration of the Galaxy. It could not unjustly be objected, however, that they did not investigate everything with such subtlety and such great care. But let it be what it will: certainly the substance of the Milky Way [Zona Lactea] was able to furnish matter abundant enough for the composition of this star. Yet because this matter was not drawn out into so exquisite a

a complete and solid consistency as is found in genuine stars (as I said before), it was subject little by little to dissolution and dispersion—whether the Sun and the manifold rays of the other stars brought this about, or it came from a resolution proper to itself.

Nor is Aristotle [Aristoteles] to be heeded here. He, who refutes the opinions of others before him on grounds reasonable enough, sets up in their place a view no less absurd and no less at odds with the truth: namely, that from the Galaxy there is produced a certain sublunary concretion drawn together perpetually out of the stars existing above it and formed from them—so that some meteor results, in the highest part of the air, not unlike comets, which he likewise supposes to be generated there again and again (building one error upon another inconsistency). For if this were so, the Milky Way's course would in no way remain in the same form, magnitude, and same celestial places throughout all the revolutions of the world since its creation. And other stars too, scattered here and there throughout the vastness of the heavens—stars no fewer or rarer than those in the circuit of the Milky Way—would likewise form some luminous concretion in the highest air, if not always, yet for the most part. But this does not happen except in that one and the same tract, and there perpetually and uniformly, without any sign of alteration.

Furthermore, as regards the Galaxy itself, this Aristotelian view would necessarily introduce a certain parallax in its lower position with respect to its higher, through the daily revolution; and so it would not observe the very same

celestial places near the same stars perpetually, both in its high and in its low position. Indeed, beyond this, according to the principles of optics, with the fixed stars seen within it and the planets sometimes passing through it, it would introduce, by a quite notable refraction, a deceptive appearance, such that the high and low [stars] would not be observed in the same place. And this refraction would be other than the one that arises from the vapors lying about the horizon. For that latter refraction scarcely exceeds the twentieth degree of altitude;

whereas this one, which is suggested as coming from the Milky Way, would sometimes reach all the way to the zenith together with the Galaxy itself. Granted, the refraction there would be smaller, yet in the lower position it would be noticed as greater. Now if Aristotle had grasped all this, schooled in the learning of the mathematicians and opticians and not relying on conjectures, he surely would not have philosophized about the Galaxy so frivolously and ineptly—or rather, he would not have talked such nonsense.

[Margin: 7] Nor, on that account, ought it to seem so very surprising that he tried to banish comets, which appear rather rarely, from the heavens, and to set them on a level with sublunary meteors—seeing that he did not blush to thrust the Galaxy, which has clung firmly to the heavens since the very first creation of the world, down below the Moon and to make it share in the elementary nature.

[Margin: 12] Indeed, the comets themselves—which we shall plainly prove in the following books are no less to be reckoned among the ethereal bodies—are for the most part formed near the territories of the Galaxy and arise there; or, while they pass through, they are caught somewhat brighter and more apparent. This is no small indication that these adventitious heavenly bodies too—though wandering, and not [fixed] in a definite place, as this star of ours is, but bound, as it were, like a kind of pseudo-planet, performing various motions that are nonetheless not wholly uncertain or confused—mostly have their close affinity with the Milky Way. [Margin: 26] So it may not unreasonably be supposed that these too, for the most part, have their cradle there. We shall discuss this matter more fully near the end of the whole work, where we have determined to treat expressly of the generation of comets.

This too is why Aristotle and the other philosophers joined the description and explanation of the Galaxy together with that of comets, even though they were ignorant of what kinship exists between them: taught by experience alone, or informed by the report of the ancients, [they held] that these hairy bodies most often had their first beginnings near the Milky Way. Nor should it seem strange to

anyone that, from celestial matter—the same as that of the Galaxy, out of which the rest

of the stars are composed—we maintain that this New Star [Nova] was put together, though less perfectly and solidly elaborated; since one may find something similar in those things which the Earth brings forth from its own bowels, namely in metals and precious stones. For what forbids us to compare the higher things with the lower, since the two are beautifully analogous to each other? For although the first matter of all metals and gems is one and the same, yet not all of them have been refined and digested to the same maturity through the energy of the natural Archeus (as Paracelsus [Paracelsus] calls it). Hence it is that some of them are corrupted and dissolved more quickly, others more slowly and with greater difficulty.

Thus pure gold endures even the force of the most vehement and prolonged fire without any harm, and is destroyed by no elementary affection, on account of the exquisite wholeness and perfection it possesses. [Margin: 17] Next in rank is refined silver, which also resists for a long time, unharmed, the fury of raging Vulcan, though at length it is little by little weakened by it. The other, more imperfect metals have less strength to endure the vehemence of the fire; overcome by it, they partly go off into smoke, partly are burnt down into a calx [calcem]—some of them sooner, some later. Hence it is that lead and tin are dissolved into smoke and calcined with little effort and very quickly, although, if the same matter from which these baser metals are forged in the bowels of the Earth had been brought up to as refined and purified a digestion [as gold and silver], they would resist the fire, on a par with gold or silver, with [Margin: 15] stubbornness and invincibility.

So too among gems great diversity is found. Some, like the sapphire, lose their color with the least effort when burned, and are affected by ignition (so to speak); others, like the diamond [Adamas] and garnets, and very many besides, suffer nothing, or as little as possible, from this.

[Margin: 5]

Let us suppose, however, that some people, by means of the art they call Alchemy [Alchemiam], are able to imitate nature. Even so, they cannot accomplish everything equally well and soundly in accordance with nature, nor as nature itself does. That this is in fact the case for most of them is no secret. For even though gold or silver may be artificially compounded in this way so as to be indistinguishable from the genuine, natural metals in color and in weight, and

even when tested against the Lydian touchstone [lapidem Lydium] — yet when everything has been thoroughly examined under the fiercest force of fire, in ashy antimony [stibio cinericio], and with the corrosive acids [aquis causticis], the products betray their imperfection, unless they are rendered absolutely identical with the natural metals at every point through the artificer's skill. That this has been achieved by very few, so far as is known, and only with great expenditure of time, labor, and money — and in the end mocked by too-late regret — is something hardly anyone fails to recognize.

[Margin: 4]

In just the same way (if one may compare great things with small) this Star could be composed in the heaven itself, out of celestial matter, in a quasi-artificial manner. Yet it could not be brought to so complete a consistency as a genuine star possesses. For that reason it was, equally with the genuine stars, exposed to the rays of the Sun and of the other stars and to the force of the heaven; and these it could not long withstand. It was therefore subject to a gradual alteration, until it dissolved completely.

[Margin: 20]

But suppose someone asks what the efficient cause may be by which this Star was formed out of celestial matter — out of the very same matter, indeed, that the Milky Way [Galaxia] shares in common with the other stars. Suppose he asks whether one ought here to posit, beyond the first and universal cause of causes, some particular Author of all created things — a perfect being [ens perfectum] over against imperfect beings [entium imperfectorum]. [Margin: 25] I have resolved to set out my own verdict on this matter not in this place, but rather alongside the universal Epilogue of this whole work, which deals with the new phenomena of the heaven — and to do so only after I have, with equal diligence, worked through an Astronomical examination of the Comets [Cometarum] as well, several of which have been observed in the preceding years. For Comets too consist of celestial matter, since in the heaven

they carry out their own motions, as I shall undoubtedly demonstrate. I have judged it consistent to hold that this New Star [Nova] drew not only a material cause but also an efficient one not unlike its own from this source — though I am wholly convinced that there are some incidental features [accidentia] in which the two have nothing in common, and in which a certain discrepancy arises between these Comets and that Star. It will therefore be more fitting to take up this matter in the place I have indicated, namely near the end of the whole work,

where I shall rehearse the opinions of others concerning the generation of Comets and demonstrate their inadequacy and extravagance, and where I shall thus prepare the way for my own assertions about these things. So we shall defer this business, judging it less prudent — and indeed premature — to treat the subject here.

In that place too I shall set out more fully the reasons why this New Star, even though it arose from the same matter as the Milky Way — matter not liable to consumption, the matter that endures perpetually unchanged — was nonetheless liable to dissolution; and I shall do so when something of the same kind comes up in the case of the Comets as well. Having thus sufficiently explained these points in this manner, I shall turn to the other question — the one concerning the Portents of this Star — in order to work out, in accordance with my own principles, the conjectures regarding its significations [Decreta].

[Margin: 15]

I am aware that there have been certain men, otherwise excellently learned, who in writings published in the preceding years maintained that these New Phenomena, which now and then appear above us, have absolutely no power or signification whatever. They were led to this verdict, as I suppose, by the fact that the pronouncements the Astrologers [Astrologi] commonly make about the effects of such adventitious stars [ascitiorum Siderum] are full of vanity and almost always turn out unfulfilled. In my own judgment, however, it does not follow from this that all power of foretelling should be denied to spectacles so wonderful, and shining forth upon us from a region so high. [Margin: 20] What does follow is merely that their import cannot be reliably divined by those who profess the Astrological Art — as sufficiently plain experience shows. Indeed, from this very fact the errors of those who, however little they themselves perceive

it, nonetheless pour forth such things too rashly, ought rather to be censured; and the weakness of human judgment, together with its proneness to go astray, ought to be acknowledged. It does not, however, follow on that account that we should conclude that God and Nature are idly toying in forming such bodies anew, and are displaying nothing of presage to the world. So if such celestial torches [faces], shining forth beyond the common custom of Nature, should be granted to carry much of the Portent in them — yet if men were to assert that whatever that import is, it is wholly removed from mortal knowledge and surpasses all human grasp, then I for my part would not deny that they decree something not too far from the truth.

[Margin: 10]

For in reality the prognosis of such foreign celestial Phenomena is exceedingly obscure, and as it were eludes the keenness of the human mind from on high — seeing that we do not have explored, with the certainty that befits it, even the faculties and influences of the Stars that have glittered in the heaven from the very origin of the World throughout so many ages of the world. From this it can come about that Astrology, which deals with the effects of the heavenly bodies, may perhaps not be able to be truthful — unless it be hindered from elsewhere and by some greater force — whereas Astronomy, which treats of their motions and appearances, cannot fail of its effect, whether it be understood and foreknown by men or not.

[Margin: 20]

Yet human industry and shrewdness has hitherto not managed to scrutinize even the motions of the heavenly bodies themselves, plain as they are to the eyes, with sufficient subtlety, nor to render them thoroughly examined — although it is most certain that there is here no underlying uncertainty. So it should be the less surprising that their effects, which are not so obvious to the senses, lie hidden so deeply, and that the efforts of mortals are frequently frustrated.

[Margin: 25]

But if ever there existed any difficulty in perceiving and in bringing out the significations of the heavenly bodies — whether of the ancient ones or of those newly emerging from time to time — surely this latter-day Star [*neoterica Stella*], which appeared in our age for more than a whole year, presents the greatest ambiguity of all, and presents the perplexed labor and the delay involved in unraveling its decrees

— especially since there have been very few, or rather no, prior examples of its kind, from which by analogy with their outcomes some Experience might have been built up. For just as the Mantic Arts [*Artes Manticae*] rest on no other Principles than experience itself, gathered through repeated practice, so here there is nothing to go on. As for a Portent of this sort, beheld by earth-dwellers out of the highest Heaven, no records of any Literature attest that one was ever seen before — except for the case in which Pliny [*Plinius*] (as we have several times cited) reports that Hipparchus [*Hipparchus*] in his own age noticed a certain new Star. But that star, since it had acquired a motion of its own (as is clearly gathered from Pliny's words), could in no way be compared with ours, which was perpetually fixed in one and the same place of the Heaven.

It is nonetheless reasonable to suppose that, just as that mobile Star of Hipparchus preceded the rise of the Monarchy of the Greeks and the growth of the Roman Empire — until nearly the whole Globe of Lands was subjected to this single City — so now too some chief and very great innovation of Political administrations is bearing down upon the coming ages. For just as this Star displayed a most rare marvel, and stood forth from the heaven, beyond the expectation of all men, as it were unforeseen, so it is likewise probable that it will have very rare, enormous, and unforeseen effects. Of what particular sort these future effects will be, I for my part judge that no mortal has any sufficiently clear perception; rather, that they are as far removed from men's foreknowledge as they once were ignorant that this Star would arise in the Celestial World at all.

From the very form, however, that it bore from the beginning — by which it shone out with a Jovial [Ioviali], bright, and broad radiance — it seems rather to presage a prosperous, longed-for, and peaceful state of worldly affairs; except that, since afterward it was tinged with a Martial [Martiali] glowing redness, it seems to mingle in something violently turbulent and tumultuous. Of Religions too — among those that derive from the Stars — it seems to portend a certain Jovial

display splendor and pomp, it appears to portend — from the Jovial figure that Iouianus [?] reported — a notable alteration, if not an outright weakening and abolition. And so, just as this Pseudo-Star, which at first shone forth with a quite conspicuous and pleasing appearance, was at length transmuted into another color, diminished in body, and finally, wholly consumed, vanished — in the very same way those who, by an outward show and surface paint more than Pharisaic, long bewitched ignorant and unwary men in their external aspect and formality, now at last feel that their own period has come. Thus the pseudo-planets, seducing men by their own plausibility and outward varnish away from the inner light of Truth, will (beyond all doubt) experience their consummation.

The fact that this Star stood high beside that point of the equinoctial colure [Colurus Aequinoctialis] also hints at something, according to the *apotelesmata* [Greek-derived: ἀποτελέσματα, "astrological effects/predictions"] of the astrologers, who have declared that this colure carries a certain hidden indication of sacred matters. Here I judge a point worthy of consideration: although this Star was so near the colure that it almost touched this semicircle with its rays, nevertheless with its whole body it stood toward the region of the spring quarter, and — with respect to the poles of the world — it marked the midpoint of the first degree of Aries. This, I think, is a sign that some greater light

is now at hand, one that will outshine the earlier darkness and gradually absorb it. Just as the Sun too, once it has passed the point of the spring equinox, prolongs the daylight beyond the nocturnal darkness that previously overcame it: so it is suggested that this insignificant light, this illumination, is now at the very doors of darkness and obscurity — because this Star occupied not before, but a little after, the boundaries of the colure, and yet right on its very threshold. And just as the Star, from the upper part of the heavens, loomed over almost the whole terrestrial globe and met the eye conspicuously, so too it foreshadows a universal [light] through very many and the most important regions of the Earth — chiefly those that are disposed from the equator [Aequinoctialis] toward the Arctic Pole

(which is also that part of the terrestrial globe that is the most habitable of all). It is credible that this portends a catastrophe of affairs. Moreover, the fact that this Star was set so high, in the eighth sphere [sphaera octava] above the orbs of all the planets, seems a conclusion: it does not lay claim to one particular region of the Earth alone, but rather embraces the whole surface of it and all the kingdoms of the terrestrial world within its decrees. And for that reason too the effects it will have are more lasting and more constant — effects which, just as it slowly and only after some years began them from its appearance, so it will continue them, prolonging them over a very long span of time.

For as to the opinion of some that the portents of this Star have now already passed, and that nothing further remains to come, I judge this — given the magnitude of the matter — to be by no means reasonable. Indeed, I am inclined to think it more probable that the Star's decrees have not yet even begun, or at least have their beginnings still very faint and hidden. And if it is permitted to conjecture from astrological reckonings of times when the first beginnings will come, when the things signified by this Star will to some extent sprout up — this may be done from the direction [directio] of the great conjunction [conjunctio maxima] that set an end to the watery trigon [Trigonum aqueum], which this Star preceded as a herald [Prodromus], and which marked, as it were, the same place with respect to the poles of the world, under which that greatest synod and meeting was celebrated. So if, then, from the place of that conjunction — which falls at the 21st degree of [Sagittarius — printer's ornament marks the sign] — toward the position of the New Star, we set up an astrological direction by right ascensions corresponding uniformly to all horizons through the meridian, it will arrive at the point that the Star marked on the equator [Aequator] in some nine years next to be counted from the time of that most weighty conjunction. And since this conjunction was completed in the year of Christ 1583, at the end of

April, the end of this equatorial progression toward the place of the New Star will fall in the year 1592 — when also the third

septenary of years, the climacteric, from the first appearance of the Star is completed.

And if any one or several persons — as I am inclined to believe likely — were brought first into the light of life somewhere around the rising of this Star, having their first cradle of life at that time, persons who are by divine foreordination the authors and executors of such great changes as the Star foretold: then they (whether one or several) will, around this very period, gradually reach their *Acme* — that is, a certain robustness of age in which they may be more readily able to attempt and to carry into action things so unusual and great — perhaps in the fourth septenary from the Star, when they attain manhood and reveal all things more fully and more openly.

Indeed, if we set up a zodiacal direction [*directio Zodiacalis*] from the place of that great conjunction to the longitude of the Star, in nearly 7 degrees — [printer's ornament] — completed by another method, through the degrees of the ecliptic (a method which also has its own weight), it will turn out at 48 years past, just elapsed, from the Star's first blaze, that is, with the seventh septenary now nearly exactly completed. Then, with the Star in its chief vigor, its decrees will be about to come to pass and to show themselves principally in the years following — especially in some of the years after that, namely after the year 1632 from the birth of Christ, or thereabouts, has been completed — when also the fiery trigon [*Trigonum igneum*], of which this Star was the standard-bearer [*antesignatrix*], will shine forth in its vigor and effect. For I judge that all the portents of this Star have a great analogy with this period of the trigons.

And if this is the seventh restoration of the trigons to the whole, from the founding of the world — just as the commonly received reckoning of the age of the world admits, so that the first falls in Enoch [*Enochus*]; the second in Noah [*Noah*] and the flood; the third in Moses [*Moses*] and the liberation of the people from Egyptian servitude; the fourth in the Israelite kings; the fifth in Christ and the summit of the Roman Monarchy; the sixth in Charlemagne [*Carolus Magnus*] and the completed transfer of the Empire to the Germans — then surely this seventh holds a certain hidden reckoning of the most Sabbatical,

and proclaims something peculiar and of great moment beyond all the rest. Here I judge a point worthy of remark: that just as those restorations of the trigons which fell on an odd number — the first, third, and fifth — were salutary to the

world, so I likewise foretell that this seventh, rejoicing chiefly in its odd number, will be a status of great good and greater happiness. Nor is this opinion foreign to the prophecies of the most ancient, the wisest, and the divinely enlightened of men, who foretold that before the universal conflagration of all things there would for a while be on earth a certain peaceful and harmonious age — in which the administrations of politics and the turbulent confusions of the variety of religions will be transformed, and adapted to a closer analogy with the divine will.

This too may be gathered, not obscurely, from the prophets themselves, who foretold that there would at some time be on earth a certain golden age, in which men will beat their swords into plowshares and their spears into pruning-hooks; nor will one nation lift arms against another, nor will they learn war any more; they will dwell beneath their own vines and fig trees, with none to frighten them — as the prophet Micah [Micheas] has it, chapter 4. And Isaiah [Esaïas], chapter 11, prophecies of the same in this manner: "The wolf shall dwell with the lamb, and the leopard shall lie down with the kid; the young child shall lead the calf and the lion together, and the cow and the bear shall feed; their young shall lie down together, and the lion shall eat straw like the ox; and the suckling infant shall play over the hole of the asp, and the weaned child shall put his hand over the viper's den; they shall not hurt nor do wickedly in all my holy mountain: for the earth shall be as full of the knowledge of Jehovah [Iehoua] as the waters cover the sea."

Then too there are the passages in Isaiah, chapter 60, which are referred to the mystical Jerusalem [Hierosolyma], that is, to a more perfect state of Christianity than there has been hitherto. Among other things it is there said: "For brass I will bring gold, for iron silver, for wood brass, for stones iron;

and you will bring it about that there is peace under your governance, and justice for the magistrates: no longer will cruelty be heard of in your land, nor devastation or calamity within your borders, but you will name your walls "salvation" and your gates "praise." What precedes and follows this passage concludes at last in these words: "This is what I, Jehovah, will hasten in its own time." A good many further passages are found, both in the Prophets and in the Apocalypse, that promise an unaccustomed and least-expected prosperity in earthly affairs — a prosperity as great as has assuredly never existed in any age of the world. Therefore, in order that the truth of prophecy may be fulfilled — prophecy that cannot deceive, since it is uttered wholly by the truthful Spirit of

God — it is necessary that such a prosperity still lie ahead, before the universal end of all things.

Why, then, in this new course of the trigons — which this unfamiliar and miraculous Star has lately preceded and, as it were, foreshadowed — should all those things not obtain their fulfillment? Most people indeed suppose that in our own times the state of religion has reached a kind of brightest, even noonday clarity, with all darkness driven off. But if that were so, where do all these controversies come from, and the great variety of opinions and the contentions of learned men who profess religion — to such a degree that the wars of their pens are now more frequent and more harmful than wars of actual arms? Where do so many hidden and open hatreds come from — the envy, the disparagements, the slanders, the vindictive passions, the ambitions, the greed, the frauds, the self-love, the intemperance, and all the other defilements of this earthly and Adamic nature, which smell as little as possible of that Olympic renewal that is to follow Christ? There is indeed reason to fear that we are mistaking for the very noonday light of the highest meridian what is still only some faint morning twilight, fouled by many mists and obscurities — a twilight in which the aforementioned astral influences upon man's natural state cannot help but be abundant and predominant. Altogether, then, it appears that another overturning of worldly affairs is at hand, both as regards Religion

and as regards the administration of commonwealths — this I forecast from this Star and from its new familiarity with the trigon. We have come to the highest point: those things will suffer utter ruin which God in the heavens rules and will rule over all the earth. I will add no more: this much will suffice for those who understand and are willing to open their eyes; for the ignorant and the blind, not even a great deal would suffice.

But suppose someone wishes to object that the end of the world is now imminent, just at hand — as they daily insist, taking the occasion from the saying of Elijah the Rabbi — and that therefore there is scarcely time left for any other transformation of affairs to take place. To them I reply that this Pronouncement of their Elijah is not sufficiently authentic, nor is it grounded in the sacred Scriptures, however plausibly it may be put forward. I judge it better, rather, to listen to Paul, who discreetly predicts that the Jews are to be brought into the Church before the consummation of the world — something that will perhaps happen during the circuit of this greatest Conjunction. This has certainly by no means yet come to pass, nor — humanly speaking — is it credible that within so short a time it could be carried into effect among so great a multitude of Jews as

has perhaps not existed since the days of their commonwealth in Palestine, and now scattered by dispersion across various lands.

[Margin: 20] Yet I do not deny that the minds of men, secure in themselves, are piously and rightly warned of the destruction of visible things, so that they may be mindful of eternity and not be infected with worldly cares. But to fix in advance the times of the visible consummation of this world — times that lie in the sole judgment and power of the Creator, and are exempt from the foreknowledge of all creatures, even of the Angels, much more of man — I hold to be impossible.

[Margin: 20] And if anyone should think it reasonable that the place on Earth over which the Star stood vertically should, before all others, have something prophetic about it — as though from that quarter the occasion and author of such great changes were to be expected — it will indeed be judged most fitting to select those regions of the Earth in whose Horizon and Meridian the Star, at the very moment of the New Moon

coinciding with the Star's first rising, occurred.

Now that New Moon happened — as regards our Meridian, at least — on the fifth day of November, at 7 hours 31½ minutes after midday, when both Luminaries, according to our calculations and the figures set out in Chapter 1 concerning their motion, were in conjunction in $23^{\circ} 27' \frac{1}{4}$ of [the sign symbol]. The Right Ascension of the mid-heaven was therefore at that time $343^{\circ} 58'$ for us. Hence the new Star had not yet reached the Meridian, but was moving 16 Equatorial Degrees toward the east. It will therefore be necessary that the quarter of the Earth which had this Star on its very Meridian at the time of the New Moon be removed from us by just as many degrees toward the east, or by about one hour. And since our Meridian is, in my judgment, about 37° distant from the west, the longitude of that place — in whose Meridian the Star was then culminating — will be about 53° . If to this we add the corresponding latitude, that is, the distance from the Equator answering to the Star's Declination, which was $61^{\circ} \frac{3}{4}$ — so that a place on the globe of the Earth at this Latitude of about 62° and Longitude of 53° , as I have said, is taken — we shall arrive at Russia, or Muscovy, especially as regards that particular quarter of it which borders, toward both the north and the east, on Finland. In that tract of the Earth, I say, this new Star, around its first beginnings at the New Moon, occupied the very Zenith of the head, where, being everywhere equally distant from the Horizon and looking down upon that same point through a right angle, it stood at its highest and most lofty. Therefore, since this Star, just as it is in itself of the strongest power, also marks out the place on Earth

from which its Decrees will chiefly issue — before all other regions situated toward the North, regions that had the Star in their very vertical point once on each single day in the daily revolution — Muscovy seems to be designated; for it is the country which, in its more northerly part and toward the east, had the Star, at the very New Moon, first rising

[Margin: 30] coinciding with this vertical position (as we have said). Whether, then, from this place such great upheavals and changes — which this unusual portent signified — will first take their occasions and sprout, and afterwards be scattered far and wide into other quarters of the World with great and lasting force, I leave to others to weigh and decide. Certainly that famous Gog, of whom mention is made especially in the thirty-eighth chapter of Ezekiel and the chapter following (and to whom Isaiah too alludes in chapters 17 and 56, and Micah in chapter 5, as Castellio will have it), and who, together with Magog, is named in chapter 20 of the Apocalypse — Gog is not inelegantly understood to mean Moscow, just as Castellio likewise interpreted him at the beginning of chapters 38 and 39 of Ezekiel, taking Gog to be the supreme leader of the Moschi and the Iberi, on the ground that the old version has him as the future "Prince of the chapter of Mosoch and Thubal."

For although in the Hebrew one reads "Mesech," and the Greek as well as the Latin translator have rendered it "Mosoch," it has been judged more probable that the Moschi are signified — since the name fits aptly enough — and that the Moschi are joined with the Iberi both in these chapters and in chapter 27, where one reads at verse 13: "the Greeks, the Iberi, the Moschi," and so on. As for the fact that the ancient version everywhere has "Thubal" in place of "the Iberi," it is gathered from Josephus that these very Iberi are joined with the Moschi in the region of Themiscyra — Josephus, who in his seventh Book, while enumerating the propagation of the nations from their original Authors, reports thus: "And Thobelus gave a seat to the Thibeli, who are now the Iberi." In the same place he also says expressly that those who were called Scythae by the Greeks were named "Magogas" after Magog — to whom the region of Muscovy too is neighboring; or rather, under this name is to be comprised that whole northern tract toward the east and north which Russia, Tartary, and the dominions of the Great Cham enclose. Indeed, Ezekiel's text plainly states that Gog, the supreme leader of the Moschi and the Iberi (as has been said), was drawn forth from the northern region, into the

to be led to the mountains of Israel. From this it follows that it will come from those very regions over whose zenith the star stood — and chiefly from Muscovy

itself, which not only by its latitude but also by its longitude, reckoned from the meridian of the West, beheld the star at its very zenith when it first appeared, around the New Moon. From many indications, therefore, it becomes probable that Muscovy is principally signified by this star, and indeed that the very Gog of the Muscovites — the leader foretold by the Prophets and in the Apocalypse — is meant: the one who, after working great slaughter throughout the rest of Europe, will at last be destroyed together with his own forces, and so the earth will be relieved of its corrupted inhabitants. For it is likely that, before that peaceful and saving age comes — the age which, as we said, the Prophets long ago celebrated in their songs — a great purging and uprooting of earthly impurities and confusions must come first.

But to explain all this in more detail — in what manner and in what order these things will display themselves — I judge to lie beyond human foreknowledge and discernment. As for ourselves, we have wished only to offer our conjectures about these matters, such as they are, by way of a general indication. The actual outcome will teach the particulars, and the order in which the several events will follow.

Furthermore, since an old prophecy of the Tiburtine Sibyl — discovered on a very ancient marble in Latin and antique characters among the Swiss, in the bowels of Mount Taurus, when the rocks were laid bare by the rushing force of snow-melt, in the year 1520, and applied by certain people (and in my own judgment not unfittingly) to this star — since, I say, this prophecy bears upon the significations of the star, I shall append it here to our conjectures by way of an ornament. For in itself it is quite remarkable and worthy of careful attention. Indeed, in a clear and unforced sense it seems that this star, together with the comets that shone in several of the following years, looks toward the imminent age of the world. Its words run as they were cited verbatim by Cornelius Gemma [Cornelius Gemma]

[Margin: 10] [Margin: 20]

in his learned treatise *On Divine Characterisms* [*De Divinis Characterismis*]:

A star shall arise in Europe, above the Iberians, toward the great home of the North, whose rays shall light up the whole circle of the lands unexpectedly. This will be in a most longed-for time, when mortals, weary of arms at last, shall embrace peace. There will indeed be strife in various ways, through the occasion of a long Interregnum, while the reins of empire are handed over to leaders. But at last the offspring of an ancient lineage will prevail, which will advance by force of arms as far as

the contrary fates oppose it. For at nearly the same time, when this star is consumed, a certain raven, its own light kindled far more fiercely by the fires of Mars [Mavors], will shut in the empire at the bounds of the Antipodes. But before this, Gaul will bow her neck to it; Britain will swim with twofold fleets to its knees; Italy, scarcely breathing again after the harsh scepters, will stretch forth her right hand to that languishing one. Yet this radiance, before the day of the mighty longing of mortals, will hide itself in the clouds of the gods. When it is extinguished, after the dread and bloody comets and fiery portents, there will be nothing more of the saving brightness of heaven. And when the firmament of heaven and the planets fight against the living things with their contrary courses, the world will be shaken to ruin: orb will clash with orb, the fixed stars will outrun the wandering planets in their course, the seas will level the high ground — and all these things, in the end, will be night, destruction, ruin, damnation, and everlasting darkness.

G. S. G.

There have been various interpretations of this prophecy by various people, from the very moment (in the time of which I spoke) that it was discovered. Most interpreted it of Charles the Fifth [Charles V], who from the outset had remarkably fortunate successes. But when in the end this did not turn out well enough, some afterwards twisted it to his son Philip, King of Spain [Philip II]. Certain people even at this present time think that the new King of France [Galliarum Regem]

the King of Navarre [Regem Navarraeum] is designated here. Others have thought up one explanation after another — in all of which I do not involve myself. For it is not my task to settle such great disputes; this much only let me say. That ambiguity, namely, that the Sibyl says this star will rise in Europe above the Iberians toward the great home of the North, is not easily disentangled from the situation of the place itself, nor from the star's own position — so much so that Cornelius Gemma [Cornelius Gemma] greatly tormented himself in order to reconcile the North with the Iberians, and to steer it toward the Spaniards, whom he calls Iberians, all too forcedly. For since Spain is not situated in the northern part, and since the star was not vertical to it, no help can be drawn from this — namely from the fact that Hector Boece [Hector Boece], the writer of Scottish affairs, alleges a certain intermingling of the Scots and the Spaniards, whence the Iberians, or Hibernians [the Irish], are said to be named, and that he had patched this together from Hibernia itself, which is much more northerly than Spanish

Iberia. But not even thus does it fit competently: since the star did not look vertically at all upon Hibernia and Scotland, even toward the more northerly tracts of those same countries. For the farthest shores of Scotland scarcely exceed the fifty-eighth degree of latitude, and Hibernia far less; whereas nearly 62 degrees were required for the star to revolve exactly above the zenith — not to add, the reckoning is to be had not of latitude only but also of longitude, insofar as it concerns the principal point at some particular time, namely when it coincides with a New Moon, as we have noted above.

It was therefore not of that Spanish Iberia — whether it received this name from the Scots and the Hibernians or not — that this Tiburtine Sibyl was speaking, but rather of those Iberians who are settled toward the North and the East, near Muscovy. And perhaps she reckoned the Muscovites themselves, together with the neighboring Scythian peoples, as Iberians, since in the Prophets too, as we indicated earlier, that Gog is called the Duke of the Muscovites and of the Iberians. These Iberians, then, who to the Muscovites

[Margin: 10]

are neighbors, or joined together with them — the Oracle did not denote the Spaniards, especially since it has these words expressly: *above the Iberians, toward the great home of the North*. And indeed it is a vast portion of Europe that Muscovy embraces, together with the neighboring Scythian and Tartar regions; not without reason did she call this the great home of the North. Most aptly, therefore, the things we earlier adduced from Ezekiel [Ezekiel] concerning Gog, the Duke of the Muscovites and of the Iberians, agree with the tract of Muscovy and Tartary — and with this Sibylline prophecy too, by which that northern Iberia near Muscovy is denoted clearly enough. And since we have already shown earlier that this unusual star lay, at the New Moon when it first arose, directly over the very zenith of the Muscovite region situated to the north — what further doubt can remain that this very star, together with this tract of earth, agrees quite aptly with the Sibylline Oracle which we have set down?

It seems, nevertheless, that the Sibyl has mixed in certain other matters, as is the way of seers, concerning the rest of Europe — matters which it is neither easy nor altogether safe to sift one by one. She also makes mention of comets, the stars of the years immediately following this one. Of these we have thus far observed seven (among which the greatest and most notable is that one which shone five years after the star's first appearance, described in the following book), and perhaps still more remain. The rest, accordingly, I shall not pursue one by one. Let others have a field in which to exercise their own judgments. Indeed, several

other Sibyls besides have brought forth prophecies of Gog and Magog to come before the final times, and have plainly foretold this star too. Among them, that Babylonian Sibyl speaks thus in a certain place:

Then a sign will be given, mighty, from Heaven divine; For a most brilliant Star will blaze again, like to a bright Crown, gleaming in the shining Sky, And that for many days.

[Margin: 13]

What clearer testimony, I ask, could be given about this brilliant Star seen in our own time? It shone far more brightly than the rest, and it was round in the manner of a Crown, not hairy or tailed as comets are. As I have demonstrated, it stood in the Firmament itself among the other fixed stars; and it lingered there not for a few days, but for a long time — indeed it lasted beyond a full year. How aptly, then, does this prophecy describe the form, the light, and the wholly Olympian situation of this Star, as well as its duration and disappearance — narrating these things as a historian would, as though they had already passed. For all of it agrees with what we ourselves have observed and demonstrated throughout this entire Work. Nor does the Sibyl pass over that great Comet which soon followed, for she speaks of it in these words:

Beneath the setting Sun, rightly called a Comet, the Star shall shine forth again.

And more fully elsewhere:

But from the time the great Star shone in the fourth year, a heavenly Sign shall come, which across the great sea shall cast its quivering flame, and over the deep Pontus.

See how plainly the Sibyl marks out the very interval of time that separated this new Star from the Comet! For nearly a full four years elapsed from the Star's final disappearance to the rising of that great Comet which followed it. And if we work all of this out scrupulously, scarcely four months were lacking — months that she seems to have left out of account. And when she speaks of the sea, she meant the vast Western Ocean; for that Comet was seen toward this very region, directly in the quarter of the Sun's setting. Those who attentively study the Sibylline books will find more on these matters separately recorded in their predictions. From these it will also be no obscure conclusion that, before the universal dissolution of all things, the gravest

catastrophes still lie ahead — catastrophes as joyful and prosperous as they are turbulent and destructive. Yet when and in what manner these will precede or follow one another is difficult to draw out, whether from this Star which foretells them, or from the Sibylline oracles, or even from the Divine Prophecies themselves. Still, it seems probable that the more prosperous of those times will not come first, but will rather follow upon a more turbulent condition of affairs — just as this Star at first gleamed with a bright and pleasing radiance, like the splendor of Jupiter, and only afterward took on the ruddy glow of Mars. And this too can be gathered from the words of the same Sibyl, where she speaks thus:

Again the God who dwells in the great Heaven shall everywhere wholly preserve the remnants of mankind; then peace and the highest prudence of truth shall flourish, and the Earth, fruitful, shall bear richer crops, no longer divided, nor enslaved thereafter.

This too the Divine Prophets meant to signify when, after the calamities that Gog will inflict upon mortals — and after his utter destruction — they proclaim a happy and peaceful condition for the Church. But since these things are too obscure and too far removed from human understanding to be drawn out clearly and distinctly into the open, I am unwilling to linger any longer in recounting and unraveling them. This is all the more so because, as I said from the outset, I would treat only sparingly and in passing this part which concerns the significations of this Star — judging it the wiser course, since prophecies of this kind are not subject to human reasoning and industry, and cannot, like the rest of the matters that pertain to astronomical knowledge, be demonstrated geometrically. And so, leaving these things to stand at their own worth, I shall now make an end concerning this Star, and turn my effort and my pen to the description of the remaining celestial phenomena of an adventitious kind, observed in the following years, which I include under the name of Comets.

Ad PROGYMNASMATUM HUNC PRIMUM TOMUM APPENDIX

Appendix to This First Volume of the *Progymnasmata*

It seems fitting, kind Reader — in keeping with our candor — that we should advise you of a few things concerning this first Volume of the *Progymnasmata*, matters which we judge pertinent both to your information and to our own duty. For we wish to make you more fully aware — even though it is plain enough here and there from the reading itself — that this book was written between the years 1582 and 1592. Afterward, however, certain things were added, and some pages were reset, so much so that it might appear that our Parent [i.e., Tycho Brahe]

spent the better part of that period of his life — from the time the new star, the chief subject of this book, first shone — right up to the last day of his life, except insofar as he had other matters in hand, going over the writing of this book as well. Others may perhaps interpret this differently; but we understand it thus: that from it we may recognize his supreme love of truth, and a certain force of destiny. Why the one was openly manifest, while the other was the secret cause of so many delays, will be told — for the former we shall speak at the beginning, and for the latter at the end.

For since in this celestial machine there lies hidden a certain inexhaustible treasure of divine wisdom, and since his care for unearthing it never ceased, it came about that, between the writing and the printing of this book, other things — partly entirely new, partly somewhat different from what had gone before — kept being discovered and brought to light. He judged that these too ought to be included in the same volume, lest he should seem either to have disappointed the reader or to have begrudged him anything. Thus it happened that, although in the year 1572 he had begun to record his observations of the star, and in 1573 had issued to the public a little book about it, he was nonetheless not satisfied with himself, and resumed this labor after several

years — once he had both established a seat for Astronomy and assembled the most exquisite instruments, in order to restore the motion of the Sun and the places of the fixed stars. For he had resolved to use these very foundations for the structure of so great an edifice — that is, for the solid explanation of so great a marvel. When the book was now nearly printed off, because in the meantime he had begun, with his own instruments, to determine the positions of eight hundred fixed stars and had assigned their places by the calculation of triangles, he decided to enrich this work with all of them too (although a few would have sufficed for his purpose). And so, when he had left two quaternions [gatherings of four sheets] of space for that section, he afterward doubled it, so that the single signature-letters K K and L L each had Octernions [gatherings of eight sheets].

Nor do we doubt that, since he had in the meantime completed a thousand stars, he would have added the remaining two hundred as well (for the most part unmeasured), had he lived. But on this occasion, lest the copies should disagree among themselves, we have thought it best to omit them. And in general the very bulk and extent of the material compelled him — if the typographical work was to proceed all at once — to advance by four separate beginnings, and to divide the Alphabets among them. Of these, the first is Chapter 1; the second is Chapter 2; the third is in the latter part of the book; the fourth in the third part. Hence it

came about that, although he had not at first intended to treat of the Moon expressly in this book — as is clear from folios 245, 463, 474, 475 — nevertheless, since some pages remained in the Alphabet once the restoration of the Sun was complete, and since in the meantime the work on the Moon was coming along, it seemed to him a splendid thing to join the Moon, the Sun's sister, to the Sun. And so, that there might be ample space, out of the quaternions P, Q, R single Octernions were made, with one further quaternion added besides, and thus the order of the gathering-marks was interrupted at P and Q. Therefore, reader, you will likewise — if at folios 245, 460, 474, 475, or elsewhere — perhaps not everywhere find the fullest agreement with the latter part of the second chapter, where the Moon's

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the restoration of his career is treated of explicitly (though we are not certain there is no inconsistency here), you should bear in mind that these later passages were worked out more carefully and brought to greater perfection, whereas those others were stated in passing and only cursorily, as belonging to the plan of a different book and to an earlier period. There was no reason, on account of a word or two of no great moment, to suppress an entire page already multiplied into very many copies, especially when the reader can be warned of the matter in three words at the foot of the page. This our Parent [Tycho Brahe] would surely have done, had he survived; and we now do it in his place.

But to pass over these matters: he left us everything in print, from the first chapter through to the conclusion, except for the section on the Moon [the *Lunaria*]. This treatise, having been taken up afresh more than once from its first principles, he at last completed in the years 1600 and 1601, exactly as it now appears, drawing very largely on the help of Christian Severin Longomontanus [Longomontanus], a man of talent and great industry, who absorbed the Braheän astronomy at Uraniborg and in close company with Brahe himself over nearly ten continuous years. We deservedly make honorable mention of him here, as our Parent had intended to do.

He was already at the point of revising these last portions, so that the book — held back for so many years now — might at last come out, and the figures had already been engraved, when behold, cut off by an untimely and grievous death, he left the work unfinished. We, however, have in good faith committed everything to print just as it stood: namely, those parts that precede the first chapter are arranged in the same order in which they lay disposed and in manuscript in the primary copy. The pages of the *Lunaria* are 28; and the

Conclusion, finally, is given just as we found it among the papers. He had written it in the year 1592. Hence in it he mentions only the five comets observed up to that point, whereas in the later years two more were added. Nor do we doubt that he would have revised this part too, and polished it all with a more severe file, had he lived this long. With him dead, we have made it a point of conscience [religio] not to change

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even the very least thing. This was also the reason why, in the case of the figure of the eclipse seen in the year 1601, shortly after his own death, we changed nothing, although a slight discrepancy crept in. On this point the following must be said: it was not the latitude of the Moon, nor the parallaxes, nor any of the principal elements that was wanting to that calculation, such that it should agree any the less exactly with the heavens in respect of quantity. The whole matter turns rather on the diameters of the luminaries alone, which optical causes of various kinds, affecting each luminary, prevent us from measuring as readily as we might. For if you take the Moon's diameter to be $30\frac{1}{2}$ minutes and the Sun's to be 31 — of which more later — the quantity will agree, all else remaining as it is. This figure, therefore, we have, as I said, left as it was, just as it was prepared by our Parent.

One thing, however, we have taken upon ourselves, knowing it to be what he himself wished: since the book is long-winded and examines the various opinions of various men, we have compiled a full Index of Subjects and Persons. Of this our labor, reader, think kindly.

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But there is yet another point we cannot pass over untouched. On page 36 he asserts, with the ancient masters of the art, that the planets in their inequalities have regard to the simple motion of the Sun. And yet afterward, while (as said above) attending to the lunar motions, he discovered — as is now apparent — that the Moon is bound by a monthly inequality to the *true* motion of the Sun, contrary to what his predecessors supposed. This was discovered, in the meantime, in the case of Mars as well; so that there is no room for doubt about the rest. And this is the cause of such great delays in the case of the other planets, while everything has to be reviewed afresh. So beware, reader, lest you take from that page a mistaken opinion that might hinder you with regard to the other planets.

Finally, in earlier days, in seeking out the eccentricity of the Sun, he used that form of demonstration which Regiomontanus taught — somewhat altered from Hippar-

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—chus and Ptolemy [Ptolemy]: in which this is assumed, that equal arcs of the Sun's circle are measured off by equal times. From this assumption he derived the Sun's eccentricity as about 3600, of the sort whose semidiameter is 100000. And yet from the observations made on Mars, by a sure and exquisite method of demonstration, the Sun's apogee comes out indeed the same, but the eccentricity not greater than 1800 — that is, half the former value; the remaining half, therefore, will go to the equant, as it does in Ptolemy in the case of the three superior planets. Thus this too will have to be followed as a novelty against the predecessors: namely, that the Sun — if we here imitate the Ptolemaic supposition — completes, in equal times, unequal arcs of its orbit; or, if in this matter we prefer to follow the Copernican [Copernicus] form together with our Parent, that it is carried around by a small equatorial circle [*circellus aequatorius*] whose center is turned upon an epicycle.

When he was questioned about this business — whether he was willing to make any mention of it in the *Progymnasmata* — "Since," he said, "the quantity of this equant is not yet exquisitely established, I shall for the present pass it by. For this business proceeds slowly, whereas I am in haste to publish the book at long last." And yet from that time on we have been made certain of this much as to the equant: that this old eccentricity is precisely double the new one, the eccentricity of the eccentric. This, indeed, is what he inculcates in Volume I of the *Letters* [*Epistolae*], folio 209, and in the *Mechanica* [*Mechanica*], folio 4, line 9.

We give this warning so that we may conveniently add the following: although the arrangement of the Theory of the Sun comes out a little differently, yet its equations nowhere vary by a single scruple [scrupulum]. This is so that you may not, if you should ever be more fully instructed in this business, suppose that you have hitherto been using a faulty calculation in the case of the Sun. You will, however, note this on folio 98, and there you will estimate the distances of the Sun from the Earth from the present values. And on folio

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471, the variation of the Sun's diameter remains within one scruple, so that at perigee it is no greater than 31 minutes — a matter that cannot be distinguished by observation except with the utmost diligence and by a special method. But in

the variation of the shadow, if the whole eccentricity of the Heaven does not produce one scruple, then the half of it will already produce something less than half a scruple. And so this book might indeed stand on its own, even if no mention of this matter were made; we, however, for the reasons indicated, have been unwilling to keep it from you.

Now, to come to the other part of our discourse: I, for my part, count it among the marvels [*in portentis loco*] that our Parent should have turned in earnest to Astronomy and to the building of his Instruments at the very moment when this star was about to appear; that he should have written about it for fully twenty-nine years; and that he should have fitted out the fixed stars to that very point of time which he survived in life by only a few months — and that even then he was already foreseeing his death. Finally, that he should have died at the very time when, the work on the new star being now complete, another new star — small, indeed, and scarcely of the third magnitude, yet again in the Milky Way — should have appeared (a thing that agrees admirably with the conclusion of the work), removed $44^{\circ}13'$ of a great circle from the place of the earlier one described in this book, in $16^{\circ}18'$ of Scorpio [♏] with latitude $55^{\circ}30'$ South, with declination $36^{\circ}49\frac{3}{4}'$, and right ascension $300^{\circ}45\frac{5}{6}'$, as we ourselves observed it here with our instruments a number of times — this is proved by trustworthy arguments.

Whether some hidden order of fate hindered him for just so long in his writing, and whether this fated course of his studies cries out, as though with raised voice, that the effects of this star will take their beginning [only after some] delay — we leave to wiser heads to consider. Certainly, if that star did nothing else,

it surely signified and brought forth

a great Astronomer.

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- Scrupulositas necessaria 273. — Necessary exactness.
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- An in eadem superficie 470. — Whether [they lie] in the same surface.
- Usus in Siderali scientia 137. — Their use in the science of the stars.

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- in altissimo aethere fuit 400. — It was in the highest aether.
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- Altitudo Meridiana minima 351. — Its least meridian altitude.
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- Cum Magorum stella 330. — [Compared] with the star of the Magi.
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- An Cometa 318. 620. — Whether it was a comet.

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- Figura illuminata undecima non fuit 736. — The figure was not [the] eleventh [to be] illuminated.
- Illuminationis causae 563. — The causes of its illumination.
- Libelli de hac Tychonici publicandi occasio 578. — The occasion for publishing Tycho's treatise on it.
- Locus ominosus 368. certissimus 384. — Its ominous location; its most certain [location].
- Inter fixas 303. — [Its place] among the fixed stars.
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- Locus ex Diggesaei distantijs 655. — Its place from the distances of Digges [Thomas Digges].
- Magnitudo 300. — Its magnitude.
- Materia qualis 641. 409. — What its matter was.
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- Solstitium hybernium aestivo facilius observabile 77. — The winter solstice is more easily observable than the summer one.
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- Spicae virginis locus tempore Ptolemaei verissimus 236. — The truest place of Spica Virginis in Ptolemy's time.
- Latitudo operose investigata 215. — Its latitude laboriously investigated.
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- Temporum certò conspiciendorum quae obstacula 697. — What obstacles there are to observing times with certainty.
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- Veteres cur reprehendantur 152. — Why the ancients are censured.
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- Umbra terrae quid 743. — What the Earth's shadow is.
- Vogelini Cometa 626. — Vogelin's comet [Johannes Vögelin].
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- Waltherus 18. 33. ejus observationes 46. vitiosa altitudo poli & obliquitas Eclipticae 46. — Walther [Bernhard Walther]; his observations; his faulty pole-altitude and obliquity of the ecliptic.
- Wernerus 17. de motu octavae Sphaerae 221. ejus observationes in Suspicionem tractae 221. in Wernerum censurae excusatio 223. — Werner [Johann Werner]; on the motion of the eighth sphere; his observations drawn into suspicion; the justification of the censure against Werner.
- Wilhelmus Landgravius Hassiae 46. quantum in fixis à Tychone differat 274. ipsius laus, instrumenta 409. ejus observationes ibid. — Wilhelm, Landgrave of Hesse [Wilhelm IV, Landgrave of Hesse-Kassel]; how far he differs from Tycho in the fixed stars; his praise and instruments; his observations, in the same place.

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- Wittichius 490. 614. de parallaxibus 671. — Wittich [Paul Wittich]; on parallaxes.
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FINIS.

ERRATA TYPOGRAPHICA.

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