

*Eclipses lunares ab anno
M.D.LXXIII ad M.DC.XLIII
observatae, quibus Tabulae
Atlanticae superstruuntur,
earumque idea proponitur*

*[Lunar Eclipses Observed from 1573 to 1643, on Which the Atlantic
Tables Are Built, and Their Plan Set Out]*

(1644)

by Govaert Wendelen (Godefridus Wendelinus, 1580–1667)

Translation by Scott Weisman



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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

Eclipses lunares collects observations of lunar eclipses made between 1573 and 1643 and presents them as the observational foundation for Wendelen's projected astronomical tables, the *Tabulae Atlanticae*. Its author, a Flemish priest-astronomer, was one of the most careful observers of his generation and a correspondent of Riccioli, Gassendi and Mersenne. The book belongs to the mid-seventeenth-century effort to rebuild astronomical tables on fresh, well-dated observations.

A NOTE ON THE TRANSLATION PROCESS

This translation was produced with the translation-pipeline. See the linked repository for details on the process.

A note on the references. A scriptural or bibliographic reference given in brackets or parentheses is, in most cases, an **editorial identification of an allusion rather than a citation printed in the source**. Books of this kind quote and weave scripture constantly without naming it, and the identification is supplied here as a convenience to the reader. Where the source does print a reference of its own, it is given as printed. **An identified allusion is not evidence that the author cited that passage** — look at the original before resting an argument on one.

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.

Notation and abbreviations

A few conventions have been applied uniformly throughout this translation, so that one quantity is always written one way. They change how a value is *written*, never what it is; where the printed source and this translation differ in notation, the source's own form is recorded in the editorial apparatus.

Numerals are Arabic, even where the source sets Roman ones. Roman numerals are kept only in headings, running headers and signatures, which are transcribed as printed.

Dates are given as year, month, day — 1572 November 11. Dates are Julian, as the source gives them, and have not been converted to the Gregorian calendar.

Times are written with raised unit letters: 7^h 36^m 12^s for seven hours, thirty-six minutes and twelve seconds. An interval longer than a day carries a raised d — 3^d 7^h. The degree and minute signs below are never used for time.

Angles are written with the conventional signs — 23° 27' 30". Early modern astronomy divides the degree sexagesimally and often runs to places for which modern writing has no common symbol; the orders used in this book are:

sign	order	the source's term
°	degrees	<i>partes, gradus</i>
'	minutes of arc	<i>scrupula prima, minuta</i>
"	seconds of arc	<i>scrupula secunda</i>
'''	thirds	<i>scrupula tertia</i>
''''	fourths	<i>scrupula quarta</i>

A **sign** is 30° — one twelfth of the circle — and is written with a raised s: 5^s 3° 57' is five signs and 3° 57', that is 153° 57'. The source uses the sign both as a place in the zodiac and as a plain unit of 30° for a motion or a distance, and this translation keeps that distinction by writing the count rather than naming a constellation.

The signs of the zodiac. Longitude is reckoned eastward from the first point of Aries.

	Latin	English	longitude
♈	Aries	the Ram	0°–30°
♉	Taurus	the Bull	30°–60°
♊	Gemini	the Twins	60°–90°
♋	Cancer	the Crab	90°–120°
♌	Leo	the Lion	120°–150°
♍	Virgo	the Virgin	150°–180°
♎	Libra	the Scales	180°–210°
♏	Scorpius	the Scorpion	210°–240°
♐	Sagittarius	the Archer	240°–270°
♑	Capricornus	the Goat	270°–300°
♒	Aquarius	the Water-bearer	300°–330°

NOTATION AND ABBREVIATIONS

	Latin	English	longitude
♈	Pisces	the Fishes	$330^{\circ}-360^{\circ}$

The Sun, Moon and planets.

	Latin	English
♌	Luna	the Moon

Abbreviations used in table headings: **Eq.** equation.

Where a table in the source spreads one quantity across separate columns for degrees, minutes and seconds, those columns have been joined into a single column and the value written whole. Where a value runs to thirds and beyond, the columns are kept, since there the columns are the notation.

[Front cover: plain paper-covered board, no printed text. Library label at upper left within a border of asterisks: "Res. 4° / Astr. p. / 491". A second, partly cropped label on the spine edge at lower left shows only "P."]

[Inside front pastedown: no printed text. Handwritten shelfmark at upper left: "4° astr. P. 491." Two dark metal clips, apparently holding the leaf for imaging rather than part of the binding, lie at the left edge and at the foot. Faint show-through of handwriting from the other side of the leaf is not legible.]

[Handwritten shelfmark at top left: "Astr. P. 491." Handwritten letter "R" in the left margin, level with the word *Observatae*.]

The Lunar Eclipses of Govaert Wendelen *[Gotifredi Wendelini], Luminarcanus*

Observed from the year 1573 to 1643 [M. D. LXXIII. AD M. DC. XLIII.], on which the Atlantic Tables [Tabulae Atlanticae] are built, and the plan [Idea] of those Tables is set out.¹

Diagram. Woodcut portrait in a rectangular frame: a bearded, moustached man with short curly hair, shown head and shoulders turned slightly to the right, wearing a plain collar. At the left of the block stands an oval cartouche containing a coat of arms on a shield, set on a pedestal; the charges of the shield are only partly legible on the scan, and no blazon is attempted. At the lower left of the block, on the base of the pedestal, stand two small cut marks resembling characters [?]; they are not construed, and the block carries no other lettering.

[Handwritten inscription to the right of the woodcut, three lines: "Clariss. Viro / Arnoldo Gregorij / Auctor[?] D.D." — "To the most distinguished man Arnoldus Gregorii [?], the author [?] gave this as a gift."]

Antwerp, at the press of Hieronymus Verdussen [Apud Hieronymum Verdussium]. 1644 [M. DC. XLIV.]

With privilege and permission of the superiors [Cum Priuilegio & permissu Superiorum].

[Verso of the title leaf: no printing of its own. The title page, its woodcut and the handwritten inscription show through in mirror image.]

¹*Luminarcanus* is Wendelen's Latin toponymic epithet, kept as printed; its identification with his birthplace, Herk, is supplied, not stated on the page.

Dedication

To the most noble and most distinguished men, Lord Antonio Sivori, Knight [Eq.], and Lord Iacobus van Buren [Jacob van Buren], Jurisconsult [I.C.], Consuls [Consulibus], and to the Senate of Antwerp, Gotifredus Wendelinus [Govaert Wendelen] dedicates and consecrates [this work].²

If I wished to prove too ambitiously that among honourable studies none is more divine than astronomy [Astronomico] — as if this had not long since been done — I would be offending against the most holy Patriarchs, Abraham, Job and Moses. I would be offending against the greatest kings — the Persians, the Egyptians, the Europeans, Alfonso, Frederick and Rudolf. I would be offending against God himself, the founder of the stars, who at his own cradle consecrated the sublimity of this same science by accepting gifts; who willed that the failing Sun should be the witness of his death, and the Moon, rising in eclipse, the witness of his burial — sealing himself as the Greatest with the greatest of signs [characteribus ... Maximis].

And certainly the science of the stars [sideralis disciplina] has nothing greater than the eclipses [deliquiis] of the Sun and Moon; nothing that so equally either terrifies the ignorant or holds the learned in suspense. The learned, even though they have somehow grasped the account of these eclipses, and seem to have been admitted more intimately into the secrets of Nature, as if they were counsellors of the heavens, nevertheless still wonder at many things more than they understand them [suspiciunt magis, quàm capiunt]. They confess that much is lacking for the perfection of the science, since they consider that over so many centuries nothing has yet been achieved, so long as eclipses cannot be gathered and predicted with certainty by computation.

A lifetime would scarcely suffice to list those whose Calculations and Tables [Calculi ac Tabulae], devoted to this one matter, survive from the remotest times onward. Yet all of them neither agree among themselves nor ever represent any eclipse in its moments without from time to time going astray by whole hours — which is too much. So it is that the very lengthy complaints of the most learned have long been in circulation; and among them even the leaders of leaders [Ducum adeo Duces], having confessed their ignorance and broken off in despair, correct the heavens, lest they should seem not to know.

Let those who expect nothing more from these studies than pleasant recreation among the amusements of leisure be allowed this with impunity. But there are others: those who must sail the Ocean now that New Worlds [Nouos ... Orbes] have been opened up; those whose very lives hang on these unknowns [quibus capite stant haec ignorata]; those for whom knowing is the

²The *Consules* of Antwerp are its burgomasters; the identification is editorial, not printed.

business of living; those who are compelled not to deform the heavens into their own images but to shape themselves wholly to the heavens. Such people have long been looking about for everything else — for happier calculations and Tables [calculos Tabulasque] — and they demand them with a thousand prayers, and even by offering ample rewards, in case they might be brought forth from anywhere. And so there is now no year in which new Tables are not struck off. Their authors vie with one another in trying to lay out the heavens by rule [ad normam expangant], and most of them promise it with great gaping mouths [magnis ... hiatibus]. But once they have stretched their jaws wide, they usually send us away hungry, as if from the table of Empusa [Empusae mensâ]; nor do they set out any other spread than one that flees at the first touch from those who grasp at it.

I myself have noticed this so many times over these 40 years and more [intra hosce 40. & quod excurrit, annos], harried by empty mockeries. So many times, while I tested now this Table and now that, I was rejected because the heavens disapproved. So many times I was thrust back, as if in disgrace, from the embrace of Urania, which I had believed most certain of all — so that at one point I seriously considered abandoning this whole line of thought altogether — had not a certain good [bonas] [recte: bonus] chance — a good Genius indeed — taken me as if by the hand and drawn me back onto the road, at once the shortest and the easiest: the road through the OSCILLATORY PROSTAPHAERESSES OF THE MOON [OSCILLATORIAS LVNÆ PROSTAPHÆRESES] and through NATURAL DAYS ALL EQUAL TO ONE ANOTHER [DIES NATVRALES OMNES INTER SE ÆQVALES]. These two physical wonders of Nature, which had never entered the mind of any mortal before me, even in a dream, I recently brought to light in my *Lampas* [LAMPADÉ meâ nuperâ], while the learned were astonished, and soon after congratulated me and, at the same time, the public.

With this first lesson, once I had withdrawn my hand from the old schoolmaster's rod [antiquae ferulae], I even began to construct TABLES [TABVLAS] for my own private use and, as happens, to rework them again and again (now for the twentieth time [vigesimal iam]). It is incredible to say with what success, with what ease, with what certainty I have learned to represent eclipses to myself, and to teach anyone at all how to represent them. For I now achieve this not within the limits of a single hour, which would have been more than enough for Ptolemy, Alfonso and Copernicus; not within half an hour [semissem horarium], which Tycho, Longomontanus, Kepler and Lansbergen would have counted a great thing (they were from time to time wrong by a whole three-quarters of an hour [ad dodrantem totum]); but to the very minutes, and to still smaller fractions of minutes — to which no human industry has so far been able to aspire even in hope.

These grand words could have seemed mere words, had I not been seen to prove them in action [AGENDO SPECTARER] — above all in your eyes, KEEN MEN, SERIOUS MEN [VIRI ACRES, VIRI SERII], who cannot be

taught to value words above deeds, and the best part of whom owes nothing to Thales, Helicon or Sulpicius Gallus [Sulpitio Gallo]. I could have shown myself, I say, with empty display and the utmost vanity, as a boastful Bombomachides [Bombomachides gloriosus], had not a most beautiful chance favoured me.

I had come to this city to visit the most distinguished man I. Casperius Gevartius [Jan Caspar Gevaerts], your chief secretary [Archigrammatéa], long my host, who was at that time most eagerly awaiting my embrace. (I believe his mind foresaw that something great was being brought to birth — something memorable to posterity, and at the same time glorious for this city — that would extend its eternity into the ages that follow us.) While I was staying with him for some days, it happened that an imminent lunar eclipse [deliquium Lunare] presented itself, to be watched on the evening of September 27 [die 27. Septembris vesperè], if the clear sky allowed. From my TABLES [TABVLIS] and Hypotheses I announced in advance that it would be of six and a half digits, a very little more [digitorum sex cum semisse pauxillo amplius]; that the middle would fall at 6^h 52^m Antwerp time [hora Antuerpiana 6. 52']; and that the end would come exactly at the eighth hour itself — but the eighth hour as the shadow of the Moon would mark it on a sundial [Scioterico], if there were one large enough; and, by the rules of the art [atque ex ar-] made and set up [confectum ac collocatum].

Origanus [David Origanus] would have put these times (above all the moment at which the eclipse ends) off by almost half an hour [in semihorium ferè] from the Tychonic Tables, and by very nearly a whole hour from the Prutenic.

All of you who heard it marvelled at this confidence; but you were more astounded still when the outcome answered the prediction — and answered it so exactly [tam partiliter] that, whereas I had declared I would not stray by even a quarter of a most contemptible minute, scarcely a flick of the finger [talitrum] was wanting.

And so that the timing should not lack its own guarantee [ne non tempori sua constet fiducia], the observation was made in the house of the noble Jacob Edelheer [Iacobi Edelherii], your Syndic. Instruments of every kind were at hand there: globes, clocks [Automata], radii [Radij], telescopes, and above all a large wall sundial [Sciotericum murale], able to yield even finer fractions of minutes of time. It had been made a little before, with truly great care and accuracy, by Gerard van Gutschoven [Gvtiscovio], a most skilled physician and mathematician.

As for the observers themselves, they were a triumvirate of lynxes [Triumviri ... Lyncei]: Edelheer himself; the most esteemed Iacobus Eyckius [?]; and that Gevaerts [Gevartivs] who is yours and mine. Besides these, Gutschoven too lay keenly in wait, at my wish, for even the tiniest slip [errorculo] that might chance to creep in.

When he could not dig out even the very smallest, he confessed that he recognized in my calculations a success that had so far fallen to no mortal.

Thus, then, I WAS SEEN IN ACTION [AGENDO SPECTATVS] — not in some remote corner, not in an obscure village, not among a herd of unskilled men, but in the Low Countries [in Belgio], the whetstone of talents; in the city of ANTWERP, the file of judgments; the most elegant city of cities, [Hebrew: הארץ-נוף משוב כל — "the height, the joy of all the earth"], a NYMPH (I say), THE DELIGHT OF THE WHOLE WORLD [NYMPHA (inquam) TERRARVM ORBIS DELICIO]. And it was before a circle [Coronâ] of men who are the pupils of this little eye of the Low Countries, whose ears here had eyes, and who certainly did not meet me with a blind back of the head [occipiti cœco].

This eclipse — so confidently predicted by me, so carefully observed by them, found to agree so exactly — seemed to everyone worthy to pass into the memory of posterity, and to bring up the rear of the column [clauderetque agmen] of those eclipses through which, within these 70 years [LXX. annos], from the year 1573 [M.D.LXXIII.] to this present [ab huncce] [recte: ad huncce] 1643 [M.DC.XLIII], battle has been waged against the stubbornness of that star. At last, in a most noble place and by a most noble deed, a most complete victory has been won — a victory which, although it was won elsewhere as well, nevertheless had to have its trophy set up at ANTWERP.

For the science of the stars [Sideralis Scientia] has long been despaired of by Alfonso, Copernicus, Tycho and Kepler, because of the inequalities in the motions [processibus] of the FIXED STARS and of the EQUINOXES handed down by Ptolemy — inequalities which no human industry has so far been able to bring under rule or under the laws of calculation, though six hundred hypotheses [sexcentis ... Hypothesibus] have been devised for them. So God has at last granted that what error lies hidden here should be understood through the good service of a citizen of ANTWERP.

That man is GEVAERTS [GEVARTIVS], at once most learned and most humane. Long ago, in his Notes on Papinius [Notis suis ad Papinium], he was the first to observe and to teach that the writer of the *Astronomica* [Astronomici Scriptorem] who has hitherto gone about under the name of M. MANILIUS did not live in the Augustan age (as even Joseph Justus Scaliger himself, together with others, wrongly believed), but is in fact FL. MANLIUS THEODORUS, nearly four hundred years later — namely the consul with Eutropius in A.D. 399 [An. Chr. 399.], celebrated by Claudian. Afterwards I, testing by calculation the position of the stars that this writer mentions (the Pleiades above all, with the sixth part of Taurus [sextâ parte Tauri], whether rising or culminating), likewise found this same age accurately; and (as others had already begun to suspect) I detected that Ptolemy's credit is untrustworthy [sublestam fidem]. His authority alone, forcing itself upon us, has nailed men's minds to a shadowy cross [Vmbratilem crucem], which

GEVAERTS [GEVARTIVS] has happily torn it down, and, in demonstrating these things [dum ista monstrat], he has crushed those two monsters

[monstra], so that from now on, with these phantoms blown away, there may be one perpetual Constancy in the motions of the Sun and the stars.

To these two Solar horses I now add my own two Lunar ones: THE EQUALITY OF NATURAL DAYS [ÆQUALITATEM DIERVM NATVRALIVM] and THE OSCILLATORY PROSTHAPHAERESES [PROSTAPHÆRESES OSCILLATORIAS]. With them, in this sixty-third year of my life, and with an eclipse that is likewise the sixty-third, I put climacteric reins on Ignorance. And I yoke the chariot in which unconquered Truth [inuecta inuicta Veritas], borne along over so many vanquished errors while the learned everywhere applaud, may CELEBRATE HER TRIUMPH AT ANTWERP [ANTVERPIÆ TRIVMPHET].

GOOD FORTUNE [FELICITER]. 1644 January 1 [KAL. IANVARIIS, M. DC. XLIV.]

THE JUDGEMENTS OF SEVERAL DISTINGUISHED MATHEMATICIANS ON THE AUTHOR: A FEW OUT OF MANY

[ILLVSTRIVM ALIQVOT MATHEMATICORVM De Auctore IVDICIA: Paucula de multis.]

REV. FATHER DIONYSIUS PETAVIUS [DENIS PÉTAU], S.J.

On the Auctarium Temp., p. 77. [*Ad Auctarium Temp. pag. 77.*]

"Godefridus Vendelinus [Govaert Wendelen], a man exceptionally skilled in astronomy, wrote to me ..." And further on: "Hence that passage of Porphyry in his book *On the Cave of the Nymphs* [de Antro Nympharum], which the same WENDELEN [VENDELINVS] explains when he says," etc.

The same author [EIVSDEM], p. 99:

"Moreover, Godefridus Vendelinus, a man thoroughly learned in these disciplines and seasoned by long practice in celestial observation, has taught us that he noticed, partly in the province of Marseille [in Massiliensi prouinciâ] and partly in the Low Countries [in Belgio], on summer days and in autumn, when the sky is at its clearest, that a certain vaporous [Greek: ἀτμώδη (atmōdē, "vaporous, steamy")] air lies over the horizon," etc.

REV. FATHER CAROLUS MALAPERTIUS [CHARLES MALAPERT], S.J.

Austriacor. Siderum, p. II. [*Austriacor. Siderum pag. II.*]

"While I was pondering these matters, there came into my hands — look — a little work by Godefridus Vendelinus on the obliquity of the Sun [de Solis obliquitate opusculum]. In it he believes he demonstrates, by arguments that are not doubtful, that the Sun is nearly three times larger (*in diameter*) than we have received from Ptolemy and others, and therefore that it is four thousand and ninety-six times [quatermillies & nonagies sexies] larger than the whole

Earth. And if he were to say it is larger by still more times, he would not find me opposing him.”

REV. FATHER IOANNES CIERMANUS [JAN CIERMANS], S.J.

In the Year of Mathematical Theses [In Anno Positionum Mathematicarum], month of August, third week.

Under the title THE SUN'S PATH [SOLIS VIA]: "Authors still contend among themselves, and the case is still before the judge — never to be settled unless the care and generosity of kings are brought to it. In this matter, certainly, we owe the palm to that most noble astronomer WENDELEN [V Vendelino]. By a discovery no less fortunate than ingenious, he balances [librat] the ecliptic upon the diameter of a circle set in the solstitial colure [in Coluro Solstitiorum] in such a way that over 9840 years it registers a difference of one degree."

Under the title THE SUN'S DISTANCE [SOLIS DISTANTIA]: "From him (*Copernicus*) Tycho, Lansbergius [Philips van Lansbergen] and others do not depart very far. Farthest of all — yet no less truly for that — departs WENDELEN [V Vendelinus], illustrious in these sciences. From the dichotomy (of the Moon) observed accurately through the telescope [per tubum opticum], he contends that the Sun's distance is as great as 3460 semidiameters of the Earth, and that the Earth is exceeded by the Sun 4096 times [partibus 4096]."

REV. FATHER FR. LINUS [FRANCIS LINE], S.J.

In a letter to Wendelen [in Epistolâ ad Vendelinum].

"Thank you for that heavenly Lamp [cælesti illâ Lampade]. I rejoice from my heart that you still have strength enough to spend yourself on these mathematical matters for the public good. The things set out there are new indeed, and worthy of so great a talent. But if, in that Greater work you are planning, you also add Hypotheses by which that constant [constans illa] equality of natural days [lium Æqualitas] is properly explained, you will certainly put posterity greatly in your debt — all the more so because, under the common hypothesis received until now (that motion is always uniform [De vniformi semper motu]), the equability of the days [Dierum æquabilitas] cannot be reconciled with the oblique motion of the Sun and with its eccentricity As for eclipses, if I obtain one, I will not fail to inform you of it with the precision it deserves.

REV. FATHER GUILIELMUS HESIVS [WILLEM VAN HEES], S.J.

In a letter to Wendelen [In Epistolâ ad Vendelinum].

By a truly happy chance there has come into my hands the four-wicked Lamp [Lampas] [Greek: τετράλυχνος (tetralychnos, "four-wicked, with four lights")] that you have held up to the mysteries of heaven [Arcanis cælestibus], to the admiration and emulation of learned men. In this charming little work, as in a spring flower, I recognise the expectation and the sure hope of fruit — that is, of a full-scale work [iusti operis] that you will bring forth before the end of your age, of your mortal life, I mean. From our meetings at Louvain

[Louanij] several years ago, more than once, I suspect that this life is already well on its decline, and I grieve for it deeply. I pray for years — no, for centuries — for mortal men who pursue the heavenly, that is, the eternal, so closely. Live on, then, most learned man, and what you do with your rod [radio] around the planets and stars, accomplish by the example of a blameless life in the minds of the people entrusted to you.

REV. FATHER IOANNES GROTHUSIUS [?], S.J.

From a letter to Wendelen [Ex Epistolâ ad Vendelinum.]

I congratulate us [Gratulor nobis] that we have come to know Your Reverence's learning [R^{dæ} V^x Doctrinæ] — and myself in particular, because I have come into great hope of demonstrating, some day — some day — a proposition of my own.

REV. DOM. PETRUS GASSENDUS [PIERRE GASSENDI], PROVOST OF DIGNE [DINIENSIS PRÆPOŒITI]

In the Life of Peiresc [In Vitâ PEIRESKII], p. 316.

One more thing must not be passed over in silence, since I myself also had some part in it. The learned and shrewd Wendelen [Godefridus VVendelinus] — at that time a canon of Condé [Condatensis Canonicus], and, while he was spending his youth in Provence [in Prouinciâ], dear to Peiresc [PEIRESKIO] — had earnestly wished that the greatest, or solstitial, altitude of the Sun be observed at Marseille [Maffiliæ]. His aim was that, being about to publish a second time his treatise [Diatribam] on the obliquity of the Sun, he might weigh that altitude from our observation, compared with the one that Pytheas of Massalia [Pytheas Maffilienſis] made about the time of Alexander the Great. He had wanted this done the year before; but his letter, brought from Dormalio [à Dormalio] [?], had been received far too late. Therefore Peiresc [PEIRESKIVS] took care in good time this year, 1636, that his wishes should be satisfied.

The same author [IDEM], in the same Life, p. 390.

He bequeathed to me (Gassendi [GASSENDI]) all his mathematical books, with all his instruments, and, from his other books, a hundred volumes of my own choosing, together with the portrait of Wendelen [VENDELINI Effigie].

The same author [IDEM], in a letter to Wendelen.

I could not wonder enough at the astonishing agreement, which you pointed out to me, between that eclipse of the Moon I observed in the year 1636 [M. DC. XXXVI.] and your lunar tables. For it cannot happen that a greater success in matters of this kind could be hoped for. *And further on [Et infra]:*

I had not seen your Lamp [Lampadem]: the two copies of it that had been sent on to Naudé [Naudæum] had been so scattered that neither of them could reach me. Reading it, I was astonished at both your sagacity and your ingenuity. And I wish with all my heart that the further Paradoxes you conceived long ago, and are now in labour with, may at last be born under a favourable star.

VERY REV. DOM. PAULUS SFONDRATUS [PAOLO SFONDRATI], CLERK REGULAR
[CLERICI REGUL.]

Of the Marquesses of Mons Fianus in Piedmont [Ex Marchionibus Montis-Fiani in Subalpinis], in a letter to Rev. Father Balthasar Corderius [Balt. Corderium] [Balthasar Cordier], S.J., Doctor of Theology. Milan, 1643 October 1 [Mediolano Calendis Octob. 1643.]

I should like to know whether Dom. Wendelen [Godefridus VVendelinus], who is marvellously learned in these disciplines (the mathematical ones), has died or not.

For my part, most reverend and illustrious sir, I am alive in that remembrance of me that is yours; in that love with which the most illustrious Marquess, your brother, has long embraced me. I am alive, I say, and full of you both. GOTIFREDVS VVENDELINVS, Canon of Condé [Canonicus Condatensis].

Preface of Govaert Wendelen to His Lunar and Solar Eclipses

[GOTEFRIIDI WENDELINI IN ECLIPSES SVAS LVNÆ-SOLARES PRÆ-FATIO]

To the eclipse-loving reader [PHILECLIPTICE LECTOR.]

In my *Lamp* [Lampade] I recently appeared to assert two prodigious paradoxes, when I declared that ALL NATURAL DAYS ARE EQUAL TO ONE ANOTHER, and likewise that THE LUNAR PROSTHAPHAERESES ARE OSCILLATORY [OSCILLATORIAS ESSE LVNARES PROSTAPHÆRESSES] — that is, equal about the apogee and about the perigee at an equal number of degrees from the line of mean motion [medij motus Lineâ]. So that these paradoxes may commend themselves even to those who marvel at them, and may turn aside from me the odium of foolish boasting (a reproach I have always held it dearer than life itself to escape), I now come to what I promised: to kindle a light on eclipses in that densest darkness, beside which the Cimmerian shades are pure noon — just as the day believed in until now has been the darkest night.

All the mathematicians in the whole world will acknowledge this and will congratulate the *Lamp*, now that oil has been poured into it. The physicists of deeper contemplation will be astonished; the magneticians will search among its hidden matters; sailors and geographers will congratulate themselves; and finally the theologians, with the purest minds, will venerate the wisdom of God in this subject too — a thing that from the founding of the world down to this very time, through so many thousands of years, lay hidden from all mortals, so that it might only now be laid open and brought into tables.

The eclipses, both of the Sun and of the Moon, on which I have built my tables easily number two hundred, besides very many appulses of the Moon to one star after another; and they are drawn from a survey carried back to the most ancient times, even to the sacred times of Joel and Isaiah [Ioëlis & Isaïæ]. But since I am not presenting the tables here for the present, and am

doing nothing other than establishing the truth of my assertions on those two propositions — which promise the most scrupulously exact moments of time for all eclipses to be sought hereafter — I shall use only those that were seen within my own lifetime and carefully observed, starting from the centennial year 1600, the year with which Tycho closed his own.

For Tycho [hic] brings forward twenty-one eclipses, of the Sun and of the Moon, seen by him from the year 1573 to 1599. But he records only the middle of each, to its hours and minutes, without any mention of the beginning or the end, or of the other phases — which is what I should have wished for above all. This has taken from us the freedom of judging, and it has left the suspicion that he adjusted the numbers to his hypotheses and tables, and represented not the business of the heavens but the leisure of his own calculation. Hortensius [Hortēsius] [Martinus Hortensius] argued this not unreasonably, and he proved it openly by bringing forward testimony from Longomontanus [Longomontano] himself, Tycho's companion and partner in his studies. I too can vouch that the eclipse he recorded in the year 1595, in April, and the other one a year later, are monstrously dislocated from their true time. This matter troubled my friend Petavius [Petauium meum] [Denis Pétau] not a little, as can be seen in his work, where he is anxiously stuck at this point.

And indeed I do not see what confidence Tycho could have relied on in recording the middle times of all the eclipses he thrusts on us, especially the lunar ones. Of some of these he saw only the beginnings, or the ends as they were ceasing; it is plain that he made a guess, in the manner of a soothsayer, about the middle of the eclipse [deliquij], which lay hidden below the horizon. And if any were visible whole from beginning to end, even these felt their own hindrances from clouds that kept running across, so that nothing could be pronounced about them clearly. So that, out of that whole number (which is not large in itself), I do not know whether we have three or four that may be trusted.

Added to these are certain hindrances, noticed (so far as I know) neither by him nor by anyone else before.

THE FIRST [PRIMVM] is what they call the penumbra [Penumbram]. Because of it, to the unwary the Moon usually, indeed almost always, seems to be eclipsed before it touches any shadow at any point; and long after the eclipse is over it is still judged to be darkened, although it has already been fully restored to its wholeness.

For since sound reasoning proves that the whole Sun pours out more light than a diminished Sun — and this is evident in solar eclipses — the Moon, on the side where it comes nearer the shadow, certainly sees less of the Sun and is less illuminated. So on that side it grows dim, turns pale, and shines more feebly than the rest of its body; and this presents the appearance of an eclipse and the image of a fainter shadow, which the unwary take even today for the true shadow and for a true part of the eclipse. And this first optical illusion [fascinum Opticum] both precedes the approaching eclipse [deliquium] and

follows it as it ceases, sometimes by 30^m, often by 20^m or 15^m [minutis interdum 30', sæpè 20' vel 15'], according as the eyes of the observers are keen or weak, clear or dim-sighted.

THE SECOND [ALTERVM] follows, but this one is now physical. Mesthlinus [Michael Mästlin] saw it at Tübingen [Tubingæ] in the year 1605, in the eclipse that was seen on April 3; and I have often seen, while the Moon is in the darkness, a kind of flock [hypsum] or hanging cloud form beneath it, as if heavy with much water. Whatever it is, it certainly counterfeits a penumbra or shadowing [vmbraginem] — that is, a second shadow — even when the eclipse has long since ended; and it sometimes lasts for half an hour. Because of it a wholly inexperienced observer could declare that the end of the eclipse extends beyond its true time.

For although it is true that the penumbra precedes the pure beginning and follows the pure end equally, by the same amount of time on either side, yet if in the meantime a mist or a soot forms and clings to the Moon, the penumbra, now stronger, makes itself felt the more, and presses on the Moon as if with doubled strength. Certainly in the year 1638, when the whole eclipse had ended at 4^h 8^m after midnight [hora post mediam noctem 4. 8'], so manifest a pallor — indeed a blackness — nevertheless clung to the Moon right up to the hour

4^h 40^m [4. 40/] that it could still be seen even after clouds had passed between, and it was arched like a shadow. I was truly astonished at this; and had I not already been taught the true end by all the phases, I might incautiously have asserted that the end came only at 4^h 40^m [hora demum 4. 40/]. So Tycho and all the ancients [Veteribus] must be pardoned if they gave the durations of eclipses longer than they should be; if from spurious ends of this kind, and from spurious calculations, they made spurious conjectures; or if they listened to the enticements of their own flattering calculations — especially since the use of the telescope [Telescopij] was not yet known.

Kepler [Kepplerus] and others, indeed, have dealt more than enough with the penumbra and the optical hindrances, and with the differences and the clouding [suffusionibus] of the eyes, so that there is no need to go over that ground again here. What in the Moon itself

I may think I have noticed as a THIRD [TERTIVM] thing is worth careful investigation. It sometimes happens that the Moon, once wholly immersed in the shadow [Vmbræ], vanishes so completely that it cannot be found unless it is searched for attentively. Tycho left this in writing about the eclipse of the year 1588; the same thing happened in the year 1620; and finally, in April 1642, we all noticed it. The Moon, that is, loses whatever light it has, just as a live coal shut up in a closed vessel does, so that nothing of it is left. But at other times it keeps the fire it has received from the Sun so well that you could doubt whether it is failing in any part, although it is already dulled by several digits [digitis aliquot]. Something of this kind happened to Gassendi [Gassendo] in April of the year 1623: when the Moon was already set in the midst of the darkness, it glowed red, shining white-hot like a burning coal. More remarkable still is this:

when the Moon is really immersed in the shadow, it sometimes keeps a bright limb for a very long time, and a spurious light that is quite clear — as if either the shadow there had become narrower, or the Moon were thrusting out little flames beyond its own body. You might say that at times it is vigorous and in health, at times it languishes and is sick, and all but ceases to live and dies; and so (if the stars have so great an affinity, a kind of kinship, with us) that it draws on itself these vicissitudes of sublunary things. Certainly what change in public affairs followed the year 1588, likewise 1620, and then lastly 1642, others may judge.

So this is my view. The Moon is a body very like the Bologna stone [Lapidi Bononiēsi]: once that stone has drunk in the heat and light drawn from the Sun, it keeps them for about two hours even in the dark, shining clearly and lighting up dark places — provided, that is, it has brought back pure rays from a pure Sun. In the same way (I say), the Moon at times shines more fully with the light it has received from the Sun, and at other times is dull and more languid, according as the Sun has lent to it more liberally or more sparingly. For the Sun too undergoes great vicissitudes of this kind, memorable examples of which I relate in my *Diluvium* [Diluvio meo].

To these I add a FOURTH [QVARTVM] difficulty [scrupum], but a slight one and of no great importance. The Earth is surrounded by its own air, and the Moon likewise by its own. How great ours is, and how far it extends upward, is not agreed among all. From the reckonings of the twilights [Crepusculorum] its height would come out at about 50 Italian miles [milliaria Italica 50. circiter], except that from the refractions it appears to be reduced to only 24 — which I hold to be nearer the truth. These 24 Italian miles are roughly the one-hundred-and-fiftieth part [pars centesima quinquagesima plus minus] of the Earth's semidiameter [semid. Terrenæ]. By this amount the Earth as a whole is larger than itself, and so it creates a larger shadow — not, indeed, a thick or dense one, but a shadow nonetheless, or rather a fringe [fimbriam] of its own shadow. Therefore, while its true shadow is (for example) 42' [minutorum ... 42/], this fringe will add 17" [17//], and by the whole of this amount the eclipse of the Moon will appear to begin earlier and to end later.

This is how the matter stands in its simple form. But — as we shall note in the FIFTH [QVINTO] place — if our air is moreover swollen with clouds or vapours, that shadow will be made denser still, and it will give the beginning of the eclipse a little earlier and the end somewhat later. This interval is not, indeed, large; yet it can be felt up to a full half of a minute of time [semissem minuti horarij]. And if a similar darkening of the Moon's air (which is perhaps no purer than ours) is added to it, the Moon's limb will appear to be touched perhaps even a whole minute of time [integrum horarium minutum] outside the true contact. So it will come about that an eclipse [deliquium] which lasted no more than three hours will be judged to have lasted 3^h 2^m [horas 3. 2/], if the state of the air is the same on both sides. Otherwise it may happen that one half of the eclipse is at times longer than the other by one minute. Although

this is of no particularly notable importance, I nevertheless thought it should not be concealed.

Still less shall I conceal a SIXTH [SEXTVM] point. This same air of ours is lowest under the Equator and the Torrid Zone, higher under the Poles, and there also denser with vapours. Others too have long since partly conjectured this and partly demonstrated it from the refractions, which the Dutch [Bataui] detected while wintering close to the Pole [proximè illum] in the year 1596, and again in 1634. Hence it comes about that in partial defects of the Moon the limb of the shadow — whether it is the northern or the southern one — always appears fringed, and frayed into certain ragged edges [laciniis quibusdam defloccatus], and quite unevenly so, according as the Sun, present and continuous in the subpolar regions, grips the air as it fluctuates with its vapours, and likewise carries fluctuating rays onto the Moon. Galileo [Galileus] too noted this in the eclipse of the year 1614, and I have observed it more than once; and in this last eclipse, at Antwerp in 1643, we all noticed it clearly.

The lowness of our air under the Equator and its height under the Poles, therefore, no longer follow the spherical figure of the Earth, but imitate to some extent an oval one — something Clavius [Christoph Clavius] and others also observe. And in this respect, certainly, I do not refuse to agree with the great men who firmly assert an oval figure for the Earth. But since this difference is not so great, nor of such consequence, as to make any great difference in the ecliptic digits [digitis Eclipticis], it may rightly be neglected — on condition, however, that an accurate account is taken of it in total eclipses without duration [Totalibus sine Morâ], when the Moon and the shadow meet in what they call the angle of contact [Angulum Contactus]. Lansbergen [Lansbergius] writes that this happened in the year 1580.

Let the SEVENTH [SEPTIMVM] point be one that, just as it has not been noticed until now, should certainly not be disregarded. When we determine by calculation the ecliptic digits of the Moon in eclipse, we proceed as if the Moon's body presented itself to us as a flat disc; whereas it is a globular body, and its lowest boss [imus eius vmbo] is nearer to us than the whole remainder of its body [vicinior]; and therefore the Earth's shadow is greater there than it would be at the centre of the Moon and of the flat disc [in Lunæ ac Disci plani centro]. Since, moreover, this shadow varies by a whole minute for each of the distances measured in Earth semidiameters [Semidiametris Terrenis] (for at apogee it does not subtend 39', at perigee about 47'), it is evident that at the boss [Vmbone] the shadow is larger by a quarter of a minute, that is by 15", than it would be at the centre of the lunar disc itself — because that boss is nearer to us than the Moon's centre itself by a quarter of an Earth semidiameter. The result is that every eclipse appears there greater, by a tenth part of one digit, than the proper measure of the calculation: in place of 6 digits, namely, a full 6 digits and 6' [toti 6. & min. 10'] [recte: min. 6., per the book's errata] are seen.

I add an EIGHTH [OCTAVVM] point. This boss of the Moon — and, as a consequence of it, the visible margins of the Moon — are not the same for all

regions. For those over whom the Moon stands vertical look upon the same boss that a straight line drawn from the Earth's centre to the Moon's centre [Lunæ centum] [recte: centrum, per the book's errata] would cut off; whereas those who see the Moon obliquely, either to the south or to the north, certainly have other bosses, which we may call parallaxic [Parallacticos], since they are bound up with the parallaxes. This difference in turn can amount to 15", and can bring it about that a lunar eclipse seen as one of six digits by those who have it vertical appears to southerners as one of 5 digits 54' [5. 50.] [recte: 5.54', per the book's errata], and to northerners as one of 6 digits 6' [6. 10/] [recte: 6.6', per the book's errata]: there the difference comes to nearly a quarter of a digit [triens digiti] [recte: vbi ferè quadrans d., per the book's errata].

I subjoin a NINTH [NONVM] point arising from this — perhaps a by-product [Parergon], but certainly a paradox. I say that the same lunar eclipse can be observed by some peoples as partial and by others as total. For if a tiny part of the Moon's body projects beyond the shadow and the angle of contact, which is seen towards our pole, it will nevertheless not also be seen towards the other pole. So we shall have a partial eclipse that is total for the Antœci [Antœci]; and conversely, an eclipse can be total for us that is partial for the Antœci. But the difference is so imperceptible that it rightly deserves to be neglected.

These things, then, and many more of the kind, are to be examined by natural philosophers [Physicis]. Just as they clear Tycho [Tychonem] and others, who never suspected anything of the sort, of the charge of error, so they warn posterity from now on not to apply themselves to eclipse observations carelessly or perfunctorily, and not to let themselves be deceived — whether by the Earth's penumbra, by the spurious light of the Moon, or finally even by telescopes [Telescopiis], which call for no less caution than those. For an eclipse [defectus] that has already been noted with the naked eye, and declared so by the judgement of all, is reckoned, if a telescope is applied, to begin only about ten minutes later [decimo ferè pòst minuto]. The reason is that the telescope sees right through to the Moon's limb still glowing red [punicantem] with some light even within the darkness, and so determines the beginnings of eclipses that much later. So much so that I do not know whether this all-too-lynx-eyed tube has brought us more benefit here than danger. Certainly I have always found all the phases of eclipses — beginnings, digits, immersions, emersions, ends — judged with no less certainty and precision by the naked eye than if the eyes were aided by a telescope. Nor, when several observers were present, do I remember their verdicts ever differing by more than the narrow margin of one, or at most a second, minute of time [minuti horarij].

Therefore, whenever I prepare to observe, I take pains to have with me several boys or young men of keen sight; and while some handle the telescopes, I attend to what others pronounce on the trustworthiness and reliability of their own eyes as well. And I would urge all who take an interest in these matters to

strive for the same — I who know that I have never been deceived by even the smallest amount.

Let this much, then, be said about lunar eclipses and about my method in them. In solar eclipses the use of telescopes must now be held not only useful but also necessary. For by their help, through projecting the image of the Sun onto a facing wall or sheet of paper, one perceives not merely the minute at which the eclipse begins and ends, but even the very second [secundum momentum]. Whether this could previously be brought out with equal success, by admitting the Sun through a tiny hole into a darkened room, I do not know — certainly not with equal ease.

And I do indeed possess a good many solar eclipses, taken down from the sky likewise with great care and skill, partly by myself and partly by most excellent practitioners [artificibus], which the plan of the present undertaking could and should have called upon. But because caution over the parallaxes is constant in them, and the parallaxes cannot be established with clarity unless the true distance of the Moon from the Earth has been ascertained — which in lunar eclipses is not so necessary — I leave them aside for the present. I am content with these lunar ones, which will amply furnish what will be proof enough to demonstrate the equality of days [Dierum æqualitas] and the oscillatory prosthaphæreses [Oscillatoriaque Prosthaphærefes]. In the same way Hipparchus and Ptolemy [Ptolemæus], al-Battānī [Albategnius] and Copernicus, and all the great souls who have flourished down to our age, sought from lunar eclipses the certainty of their demonstrations in restoring the motions. Therefore, having avoided that winding detour as far as it can be done, we shall proceed by a road at once the shortest and the smoothest — provided, however, that we first remove the stumbling-stones lying in the way concerning places [Locis], and take care to lead more smoothly the distinguished men who have tripped over them.

ON PLACES, and the Differences of Meridians [DE LOCIS, & Meridianorum differentiis]

If all observations could be duly carried out in one and the same place — a place, that is, which in the perpetual clearness of its sky was never overcast with clouds (as is true of Egypt, and is reported of Babylonia) — and if there were schools [Gymnasia] established in that same place for propagating these disciplines, such as was the college of the Chaldaeans and priests of Jupiter Belus [Iouis Beli] at Babylon, such as that of the sacred sanctuaries [Sacrorum Adytorum] in Egypt, or the Museum at Alexandria, a part of the palace, in which mathematicians and learned men were maintained at public expense, then there would be no need to wander so ambitiously from one place to another, to inquire what the sky may perhaps have granted those people there while it begrudges it to us here, and often denies us all view just when we are intent on the opportunity. Rich in our own domestic resources, we could be spared this trouble — not to say distrust — through which we are now and then

unjust to others, perpetually angry with ourselves, and a nuisance to the very work we strive to advance. As it is, since this has been denied us both by the habits of many princes (very unlike the Ptolemaic kings indeed) and by the nature of places, so that only from private persons, and not at public expense [publico sumtu], and these studies are not pursued in one and the same region or town, we must repeatedly go out to others and inquire what they saw while we were blind — indeed, what they observed at the same time as us and in the same way — pursuing it down to the most exact minutiae of time (as far as that can be done), so that it may be understood how far places diverge from one another, whether toward the east or toward the west. And so, since a method of establishing longitudes [ratio Longitudinum constituendarum] is sought with so many prayers, and even with prizes offered; and since it is agreed that no more accurate method can be undertaken than through lunar eclipses, which alone are pointed to as the guides [magistræ] for perfecting geography and, from there, for organizing navigation — I shall have accomplished something abundantly great here if I set out the more certain longitudes which a number of notable places hold relative to one another, as I have carefully investigated them, and if I give an indication of them somewhat more certain than others have so far given, a starting point from which one may safely proceed further. These places are: Madrid [Madritum], Paris [Parisi], Goes [Gouza], Antwerp [Antuerpia], Brussels [Bruxella], Leiden [Lugdunum Batavorum], Amsterdam [Amsterdamum], Aix [Aquæ Sextiæ], Digne [Dinia], Herk [Herca], Franeker [Francica], Liège [Leodium], Tübingen [Tubinga], Hven [Huenna], Copenhagen [Hafnia], Rome, Prague, Linz [Lincium], Alexandria, Cairo [Cairus], and Aleppo [Alepum]. There is no need to add more, since once these are correctly placed, all the places near them readily present themselves.

First, then, I assert that Digne and Herk lie under the same meridian. This follows from the eclipse that occurred in the year 1635, on August 28: Gassendi [Gaffendus] observed several of its phases at Digne at the same moments at which I observed the same phases at Herk. From this it is clear to me with certainty that these two places do not differ from each other even in the slightest. Nor do I see Franeker holding a very different position. For besides the geographical maps [Tabulas Geographicas] by which I extended the meridian with the greatest accuracy from the very top of the tower of Herk [ex summo fastigio turris Hercanæ], the beginning of the eclipse seen in the year 1638 at the winter solstice [in Bruma] also bears this out: it was noted both at Herk and at Franeker at 1^h 33^m 30^s after midnight [hora post mediam noctem i. 33. 30], in an admirable agreement with the geographical maps I measured — unless, at most, Franeker is more easterly by a single minute.

Between Digne and Aix (which is more westerly), there in fact fall more than four minutes of time [minuta horaria supra quatuor] — indeed, even 4^m 30^s [4'. 30"]. For in the year 1605, when I wished to extend the meridian of Forcalquier [Meridianum Forcalariensem] down to the Mediterranean Sea, I noted from the very summit of Mount Luberon [montis Leberonis] that Aix

lay to the west by more than five Provençal leagues [*Leucis prouincialibus quinque*], while Digne lay to the east by a full seven. I could not work out a smaller interval than that. The road from Digne to Aix also supports this: it is 14 leagues, that is, one degree of a great circle. The latitude of Aix is $43^{\circ} 33'$ [gr. 43. 33'], and that of Digne $44^{\circ} 6'$ [44 6'], a difference of 33 minutes, or not quite eight full leagues. If you subtract the square of these, 60, from the square 196, the remainder will be 136, whose root is about 12; and that is the distance between the meridians of Aix and of Digne on that parallel. There, 10 leagues of this kind make up a degree, which again confirms more than 4 minutes 36 of time [*minuta horaria suprà 4.36'.*].³

Further, between Herk and Brussels there are likewise $4^m 30^s$ of time [*horaria fcrupula 4'. 30''.*], no less, or at most $4^m 36^s$ [*4."36'.*]. This is proved by the itinerary measurements [*stadiafmi*] I have carefully computed and weighed, and it is brilliantly confirmed by all the observations of van Langren [*Langereni*] [*Michael Florent van Langren*] compared with my own, as the eclipses will demonstrate in their proper years and occasions. Just as Digne and Herk therefore hold the same meridian, so too Aix and Brussels certainly fall under one and the same meridian, together with Marseille in Provence [*Maffilia Prouinciæ*], Antwerp in the Low Countries [*Antuerpia Belgij*], and Bergen in Norway [*Berga Noruegiæ*] — three most noble trading ports [*Emporia*]. From their dignity I take the liberty of naming it, so that it may be called the EMPORETIC MERIDIAN [*MERIDIANVS EMPORETICVS*]. From it Brussels and Aix vary scarcely the least amount, while Herk and Digne are distant from it by $4^m 36^s$ [*4.'36''.*] — values determined precisely enough in this way, and to be confirmed again and again.⁴

With this Emporetic meridian established, I can now easily define the meridian of Madrid from the eclipse that van Langren [*Langerenus*] observed accurately there in the year 1631 — as Hortensius did at Leiden, I among the Bethasii [*Bethafiis*] (that is, almost at Herk [*hoc est paullò minus Hercæ*]), and Schickard [*Schiccardus*] [*Wilhelm Schickard*] at Tübingen. That eclipse plainly taught me that between Madrid and Herk there lie 33 minutes of time, precisely enough; that Herk is distant from Leiden by 4 minutes (which is in any case clear chorographically [*Chorographicè*]); and that Tübingen is distant from Herk by 13 minutes, precisely — which will also become evident from other sources.

I have found on several occasions that Paris [*Lutetiam Parifiorum*] is distant from Herk by 18 minutes; that is, from Leiden by 14 [14'], from the Emporetic meridian by 13, and from Tübingen by 31. This is also an observation Hortensius made long ago, and it now squares entirely with the experiments of Gassendi, who sets Aix 14 minutes away from Paris.

³the page sets this value as "4.36'." with the prime after the 36, where the same page elsewhere sets "4'. 30'" and "4.'36'".

⁴the page sets the three minute-and-second values of this paragraph with the marks placed differently: "4'. 30'"., "4."36'." and "4.'36'".

Moreover, since it is now well enough established that Hven (and, what is very nearly the same, Copenhagen) is 12 minutes distant from Tübingen — as Kepler proved in his *Optics* [in *Opticâ fuâ*] — let it be taken as certain that between Herk and Hven there are 25 minutes, precisely enough; and Phocylides [Johannes Phocylides Holwarda] sets Hven the same number of minutes from Franeker, as nearly as possible. Hven, then, is distant from the Emporetic meridian by 30 minutes, precisely enough; from Paris by 43, a little more; from Madrid by 58, quite plainly; and (what is most worth noting) from Toledo by one whole hour.

The distance of Rome from my own Herk I hold with the greatest certainty to be likewise 25 minutes [25']; the eclipses of the years 1616 and 1635 taught me this, and indeed with great exactness [fanè quàm partiliter]. Thus Rome and Hven have one and the same meridian, so that I am astonished that Kepler [Kepplerum] and I agree so exquisitely in defining it.

We now have, therefore, three most noble meridians — the TOLEDAN, the EMPORETIC, and the ROMAN [TOLETANVM, EMPORETICVM, ET ROMANVM] — separated from one another, with the utmost precision and equally, by half an hour [Semihorio].

I come to the meridian of Prague, which I see has not been reconciled very successfully with those just set out, by Kepler and other great men. I have detected that it lies at least 38 minutes from Digne, that is, at least 42' from Aix and the Emporetic meridian, if not 43. This was dictated to me by the eclipse of the year 1601 in December: I had its middle at Digne at 6^h 11^m [horâ 6. min. 11'], or at most 12^m; at Prague it was at 6^h 50^m [6. 50'], no less. Again, at Valensole [Valentiolæ] (a place roughly midway between Digne and Aix), the eclipse of the year 1603 on May 24 was accurately observed by me, and its middle was found at 11^h 38^m [horâ 11. 38'], which at Prague was 12^h 18^m [hor. 12. 18'], no less — as will appear more fully under those years. In no way, therefore, is Prague nearer to Digne than by 38 minutes. That it is likewise distant from Herk by the same amount was established for me by the eclipse of the year 1628, which had its middle at Herk at 9^h 30^m [horâ 9. 30'] precisely, and at Prague at 10^h 9^m [hor. 10. 9']; this too will become clear under that year. So it is plain, even from this alone, that Digne and Herk lie under the same meridian, and that Prague is distant from it by at least 38 minutes — which, look, the road measurements [Stadiasmi] in any case also yield.

Tübingen [Tubinga] (as has already been said) is distant from Herk by 13 minutes [min. 13], or a trifle more; from Leiden [Lugduno Batauorum] by at least 17, or even 18 if we listen to Hortensius; and from the Emporetic meridian [Meridiano Emporetico] by a full 18' — nor do the most recent maps admit a narrower interval. Nuremberg [Noriberga] is more easterly than Tübingen by no fewer than 8 minutes. Nuremberg is therefore distant from Herk [Hercio] by no less than 21 minutes, and from the Emporetic meridian by 26, precisely enough. From there to Prague are counted 36 of those great German miles

[Milliaria Germanica illa magna 36], which cannot amount to fewer degrees than something over four [quàm supra quatuor]. Thus between Nuremberg and Prague there cannot be fewer than 17 minutes. Prague, I say, is no nearer to the Emporetic meridian than 43 minutes; that is, to Herk and Digne no nearer than 38; and finally to Goes [Gouzâ] than 45 minutes — which Lansbergen has rightly. And, as a consequence of all this, this same Prague now lies from the meridian of Rome and Hven [Romæ & Huennæ] not 5 minutes, as Tycho conjectured; nor 6, as Kepler [Keplerus] supposed; nor 10, as the same Kepler wished; but plainly 13, if not 14'. Let that stand as settled.

I come to Linz [Lincium], which Kepler everywhere makes 4' more easterly than Prague — contrary to his own wish [contrà quàm ipse optat] and contrary to what is right. For it can scarcely be moved more than a single minute. I, at any rate, found through the eclipses of the years 1616 and 1617, and finally most clearly that of 1624, that Linz is distant from Herk by 39', or at most 40, and no more; and from Brussels [Bruxellâ] by 44, or at most 45'. All of this those years will show plainly.

How far this, indeed, stands in accordance with Kepler's wish, let him say himself in his own words, in the Precepts of the *Rudolphine Tables* [Præceptorum in Tabulas Rodolfinas], p. 38:

"I confess that I am not satisfied. For I should like to put Prague under the meridian of Linz [Meridiano Lincienfi], and so to move every place in Bohemia, Silesia, Poland, Hungary, Lower Austria and Styria 4 minutes toward the east; that is what the itinerary distances seem to require. I should like to move the meridian of Nuremberg further toward the west. But whoever does this will run into trouble either with the recent maps or with the observations of eclipses. Therefore, as in a tangled lawsuit, so far as the small minutes are concerned, let the reader take this catalogue as an interlocutory ruling [loco Interlocutoriae]; and let him also set his own hand to the work, starting from his own place, and fit the whole neighbourhood by means of the following precepts"

See how, despairing of his own figures, he wishes a greater distance to be assumed between Nuremberg and Prague — greater, indeed, by 4 minutes: that is, in place of the 12' he assumes, that at least 16' be admitted. I have already asserted 17', and so have satisfied his wish.

These, then, are the most important places within our Europe. Once they are correctly located, a step has been taken toward determining the others that lie between or around them, so that there is no need to dwell over-fussily on each of the places on which my eclipses rest. Outside Europe I have two, Cairo [Caïrum] and Aleppo [Aleppum], which point to Alexandria and Babylon. From their known position the quantity of the true monthly period [veri ... Menstrui temporis] must at last be derived anew, by comparing the observations of the ancients with our own — something that until now could not be done with such confidence.

Cairo, then — the most celebrated emporium of Egypt, and indeed of the whole world — was found by me, from the eclipse observed in the year 1635, to be more easterly than Digne and Herk by 1^h 47^m [hor. 1. 47']. For the eclipse which, in the month of August, began for Gassendi and for me at 1^h 29^m after midnight [horâ post mediam noctem 1. 29'], and was immersed at 2^h 28^m [horâ 2. 28'], marked at Cairo [Cahiri] the hours 3^h 15^m and 4^h 16^m [horas 3. 15' & 4. 16'] — so that the difference (taking the middle) is plainly as great as I have said. Since, moreover, Alexandria is more westerly than Cairo by 5 minutes according to the most accurate tables of the moderns, it is evident that Alexandria is distant from Herk and Digne by 1^h 42^m [hor. 1. 42']. Rome, on the other hand, is distant from it, most plainly, by 1^h 17^m [hor. 1. 17']; in place of which Ptolemy, in his *Great Syntaxis* [Magnâ fuâ Syntaxi], repeatedly gives 1^h 20^m [1. 20']. That discrepancy is not so very great compared with the one his *Geography* shows: 1^h 35^m [hor. 1. min. 35]. The smaller distance is also favoured by the chart of the Mediterranean Sea carefully made by Bartholomæus Crescentius [Bartolomeo Crescenzio]. Although he set out no longitudes, yet, from a comparison of the latitudes, the interval drawn between Rome and Alexandria scarcely admits anything more than 19° [partes 19.] — that is, 1^h 16^m [horam 1. 16'], or at most 17. This is the true distance between Alexandria and Rome, thus derived once for all from the heavens.

There remains Aleppo. There our eclipse — the one observed at Digne and at Herk — is recorded to have begun at 3^h 28^m [horâ 3. 28'] and to have been immersed in the shadow at 4^h 27^m [horâ 4. 27'], so that there too this whole struggle lasted 59 minutes [59'], exactly as many as I found at Herk. It is therefore certain that the observers were diligent, and that the observation itself is sure, excellent, and one that may be relied on. From this we are also made more certain that Babylon (the storehouse of the most ancient observations) is not distant from Alexandria by more than 50 minutes [50'] — the figure Ptolemy repeats so often in the *Syntaxis*, although in the *Geography* he extends it to a whole hour and a quarter, here again differing from himself by a large interval.

These disagreements of the *Syntaxis* with the *Geography* lead many to think that the two works are not by the same author — a doubt they entertain in vain. For in the geographical work he copied Marinus (lightly corrected), and any other authors besides; in the astronomical work he followed Hipparchus and (unless every conjecture deceives me) Menelaus at Rome [Menelaum Romanum]. That was the sole reason why he departed so far from himself. For Menelaus, when he compared his observations with those of the Alexandrians, had before his eyes at Rome the map of the world published by Agrippa on tablets — tablets as much more accurate as Caesar's care and expense surpassed the private studies of all the Greeks. No wonder, then, that he came so close to the true modern values [cum hodierno vero paria fecerit]. For Agrippa's diligence was such that Pliny [Plinius; Pliny the Elder] repeatedly tests Greek

writings against that balance. And I seem to see that it was from that author that the practice arose of rating each degree of the terrestrial circle at 500 stadia [500. ftadiis], whereas before that time the settled opinion had been that 700 stadia [ftadia 700.] were owed to it. Certainly others too — Snellius [Willebrord Snel] among them — have noticed that this doctrine, which assigns 500 stadia to a degree, is older than Ptolemy.

If, then, Ptolemy had written at Rome (which I believe he never saw), he could have drawn us a far more exact *Geography* from the public tablets that the basilicas and porticoes displayed — tablets not of one prince alone, but from as far back as Augustus Caesar and his son-in-law Agrippa. This was certainly the concern of other emperors too, but above all of M. Antoninus the Philosopher [M. Antonini Philosophi; Marcus Aurelius]. No one will any longer doubt that his *Itinerary* is genuine, true and legitimate, who reads these words in P. Victor as edited by Onufrio [Onofrio Panvinio] (in the book *On the Regions of the City*, Region IX): BASILICA ANTONINIANA, WHERE THE RECORD OF THE PROVINCES IS [BASILICA ANTONINIANA VBI EST PROVINCIARVM MEMORIA]. I was reminded of this passage by the most distinguished GEVARTIVS [Gevaerts], my host while I was publishing this, among a number of other things bearing on the same subject, which he is now preparing for the press, already well advanced, together with Antoninus's books ΤΩΝ ΕΙΣ ΕΑΥΤΟΝ [Greek: τῶν εἰς ἑαυτόν (tōn eis heauton), "(the books) to himself" — the *Meditations*].

But let us leave Ptolemy and the ancients and attend to the matter in hand. Let us set before our eyes a kind of synopsis of the places already mentioned, beginning from the first meridian [primo Meridiano], on which I have fixed my Tables.

ON CONNECTING THE FIRST MERIDIAN WITH THE OTHERS [DE PRIMO MERIDIANO CVM ALIIS CONNECTENDO.]

So, in order to set out the position — if not of all places on the whole globe, then at least of those I have already mentioned — that is, to lay out the skeleton [Skeleton] of a geography to be founded afresh, I have decided to establish as first meridian the one that runs from the Arctic Pole to the Antarctic through the middle of Iceland, and through two towns there, Holam [Hólar] and Scaltholam [Skálholt], and is drawn out into the middle of the Atlantic Ocean, equally distant on either side from the nearest promontories of Africa and America, which are called Cape Verde [Caput Viride] and Cape of Saint Augustine. Many maps and terrestrial globes already take their starting point [Initium] from that same place; and besides, Nature herself seems to invite me here, since nowhere has she divided the lands from pole to pole more plainly than by this vast element.

My choice is also favoured by an ease of calculation that should not be passed over. In other meridians and tables the calculation is more troublesome, and so also more exposed to errors, since times must be added for some places and

subtracted for others — a slippery and tedious alternation indeed. There will be nothing of that kind in my Tables, which admit addition alone.

From this first circle, then, which I call the ATLANTIC MERIDIAN [MERIDIANVM ATLANTICVM] (just as I call my Tables the ATLANTIC TABLES [TABVLAS ... ATLANTICAS]), I enumerate these places as follows — although perhaps the certainty and reliability of them all will not be the same.

Catalogue of places [Locorum Catalogus.]	Addition [Add. Hor. m. fec.]	Longitude [Longit. Gr. m.]	Latitude [Latitudo Grad. min.]
Toledo, Spain [Toletum Hispāniæ.]	1 ^h 18 ^m 0 ^s	19° 30′	39° 54′
Madrid, Spain [Madritum Hispāniæ.]	1 ^h 20 ^m 0 ^s	20° 0′	40° 27′
Paris, France [Parifij Galliæ.]	1 ^h 35 ^m 36 ^s	23° 54′	48° 52′
Lleida, Spain [Ilerda Hispāniæ.]	1 ^h 38 ^m 0 ^s	24° 30′	41° 12′
Valence on the Rhône [Valentia ad Rhodanum.]	1 ^h 44 ^m 0 ^s	26° 0′	44° 35′
Lyon, France [Lugdunum Galliæ.]	1 ^h 45 ^m 0 ^s	26° 15′	45° 16′
Goes, Zeeland [Gouza Zelandiæ.]	1 ^h 46 ^m 36 ^s	26° 39′	51° 29′
Marseille, Provence [Maffilia Prouinciæ.]	1 ^h 48 ^m 40 ^s	27° 10′	43° 19′
Antwerp, Brabant [Antuerpia Brabantæ.]	1 ^h 48 ^m 40 ^s	27° 10′	51° 12′
Bergen, Norway [Berga Noruegiæ.]	1 ^h 48 ^m 40 ^s	27° 10′	60° 30′
Aix, Provence [Aquæ Sextiæ Prouin.]	1 ^h 49 ^m 0 ^s	27° 15′	43° 33′
Brussels, Brabant [Bruxella Brabant.]	1 ^h 49 ^m 0 ^s	27° 15′	50° 48′
Leiden [Lugdunum Bataurorum.]	1 ^h 49 ^m 36 ^s	27° 24′	52° 11′
Mechelen, Low Countries [Mechlinia Belgij.]	1 ^h 50 ^m 0 ^s	27° 30′	51° 0′
Forcalquier, Provence [Forcalcarium Prouinciæ.]	1 ^h 50 ^m 30 ^s	27° 37′	43° 54′
Leuven, Brabant [Louanium Brabantæ.]	1 ^h 51 ^m 0 ^s	27° 45′	50° 50′
Valensole, Provence [Valentiola Prouinciæ.]	1 ^h 51 ^m 30 ^s	27° 52′	43° 52′
Amsterdam, Holland [Amsterodamum Hollandiæ.]	1 ^h 51 ^m 30 ^s	27° 52′	52° 25′
Digne, Provence [Dinia Prouinciæ.]	1 ^h 53 ^m 36 ^s	28° 24′	44° 6′
Herk, Low Countries, the author's native town [Herca Belgij Auctoris patriæ.]	1 ^h 53 ^m 36 ^s	28° 24′	50° 53′

Table continues on the next page.

Table continued.

Catalogue of places [Locorum Cathologus.]	Addition [H. / //]	Longitude [G. ']	Latitude [G.,]
Franeker, Frisia [Franecara Frifonum.]	1 ^h 54 ^m 0 ^s	28° 30′	53° 12′
Calidianum, Provence [?] [Calidianum Prouinciæ.]	1 ^h 55 ^m 30 ^s	28° 52′	43° 36′
Liège, Low Countries [Leodium Belgij.]	1 ^h 55 ^m 45 ^s	28° 56′	50° 40′
Emden, Frisia [Emda Frifonum.]	2 ^h 0 ^m 0 ^s	30° 0′	53° 32′
Cologne [Colonia Agrippina.]	2 ^h 4 ^m 0 ^s	31° 0′	50° 57′
Tübingen, Germany [Tubinga Germaniæ.]	2 ^h 6 ^m 40 ^s	31° 40′	48° 34′
Stuttgart, Württemberg [Stuccardia Wirtembergiæ.]	2 ^h 6 ^m 40 ^s	31° 40′	48° 49′

Catalogue of places [Locorum Cathologus.]	Addition [H. / //]	Longitude [G. ']	Latitude [G.,]
Verona, Italy [Verona Italiae.]	2 ^h 13 ^m 0 ^s	33° 15'	45° 6'
Kassel, Hesse [Caffellæ Haffiæ.]	2 ^h 13 ^m 0 ^s	33° 15'	51° 19'
Nuremberg, Germany [Noriberga Germaniæ.]	2 ^h 14 ^m 45 ^s	33° 41'	49° 27'
Copenhagen, Denmark [Hafnia Daniæ.]	2 ^h 18 ^m 0 ^s	34° 30'	55° 43'
Rome, Italy [Roma Italiae.]	2 ^h 18 ^m 30 ^s	34° 37'	42° 3'
Hven, Denmark [Huenna Daniæ.]	2 ^h 18 ^m 30 ^s	34° 37'	55° 55'
Wittenberg, Saxony [Witteberga Saxonæ.]	2 ^h 23 ^m 0 ^s	35° 45'	51° 53'
Ingolstadt, Bavaria [Ingolftadium Bauariæ.]	2 ^h 23 ^m 0 ^s	35° 45'	48° 42'
Munich, Bavaria [Monachium Bauariæ.]	2 ^h 24 ^m 0 ^s	36° 0'	48° 2'
Naples, Italy [Neapolis Italiae.]	2 ^h 26 ^m 30 ^s	36° 37'	40° 42'
Frankfurt an der Oder [Francofurtum ad Oderam.]	2 ^h 27 ^m 0 ^s	36° 45'	52° 20'
Prague, Bohemia [Praga Bohemiæ.]	2 ^h 31 ^m 45 ^s	37° 56'	50° 6'
Linz, Austria [Lincium Auftriæ.]	2 ^h 33 ^m 0 ^s	38° 15'	48° 16'
Alexandria, Egypt [Alexandria Ægypti.]	3 ^h 36 ^m 0 ^s	54° 0'	31° 11'
Memphis [Memphis.]	3 ^h 40 ^m 45 ^s	55° 10'	29° 48'
Cairo, Egypt [Cahirus Ægypti.]	3 ^h 41 ^m 0 ^s	55° 15'	29° 50'
Aleppo, Syria [Aleppum Syriæ.]	3 ^h 52 ^m 36 ^s	58° 9'	37° 20'
Ancient Babylon [Babylon antiqua.]	4 ^h 25 ^m 0 ^s	66° 15'	35° 0'

These, then, are the places that have chiefly helped me in determining the times of eclipses — if not all of them, then certainly most; and on them the restoration of the motions, lunar as well as solar, is built. The European places alone, few as they are, supply enough evidence by which all the EQUATIONS OF DAYS [DIERVM ÆQVATIONES] may be done away with, the OSCILLATIONS OF THE LUNAR PROSTHAPHAERESES [LVNARIVM PROSTAPHÆRESIVM OSCILLATIONES] established, and the constancy of my Tables demonstrated — if it is clearly established [fi liquidò confitet.]

— that the observations of the times were made duly and correctly. On these too a few things must be said in advance.

TEMPORIS OBSERVANDI METHODVS

The Method of Observing the Time

Most people regard it as the royal road to hunt down the beginnings, phases and ends of lunar eclipses by the altitudes of the fixed stars, and then, once a star's altitude is given, to determine the time by working out triangles. That this method is also the safest in solar eclipses is not in doubt — provided, however, that the instruments are reliable and their handling skilled. Yet both of these can be exposed to countless errors [sexcentis erroribus, literally "six hundred errors"]: when the instruments are made of wood, or of some unstable material that readily feels changes in the air; when the plumb line wavers; when the sight trembles; when everything shifts about; and — even if none of these stands in

the way — some hidden deception always creeps up on even the most attentive eyes and hands.

For if the instruments are small, with divisions that are too fine, almost nothing is achieved, and to boast of them is childish. If, on the other hand, they are of a proper size, then their weight makes them hard to handle — not to say unmanageable — and far too refractory for work as delicate as this.

So — I might almost say — I laugh when I read Kepler [Kepplerum] hunting for the times through the culminations of stars by precisely this method. "We used," he says, "large quadrants for noting the arrivals of the stars at the meridian" [*Adhibuimus (inquit) Quadrantes magnos notandis appulsibus siderum in Meridianum*]. For I do not see how the culminations of stars can in any way be properly elicited with quadrants, however large. With them, those culminations were reckoned to take place when a given star was judged to have reached the prescribed altitude. How deceptive and slippery this is — not to say impossible — anyone at all can understand.

First, it is necessary to have a most accurate latitude for the place where an observation of this kind is made, not off by even half a minute; if there is the slightest error in it, all diligence is in vain.

Next, if in addition the true declination of the star adopted differs even in the least, the error will grow further, and the method will not yield as much precision in the time as was hoped.

There is a third drawback besides — even if the earlier ones are counted as nothing: any star one is observing lingers long and much at the same altitude around the culmination itself, and makes no change that can be perceived. So it happens that stars may be judged to be culminating some minutes before they actually culminate, and may be declared to be culminating only long after the culmination has taken place.

My judgment, therefore, is this: the Keplerian culminations, which Kepler believed he had hunted down and caught by that method, may have preceded the time he asserted by several minutes — or may even have followed it.

What better, then, can be put in its place [*Quid ego reponetur melius?*] [*recte: Quid ergo, per the book's errata?*] I will say what my own practice is, and show a way that no one will afterwards regret following. This, then, is what I do.

Wherever I am living, I always aim at one thing: to obtain the meridian of the place as exactly as can be done. Nor is it difficult to lay it out with the help of the Pole Star, whose distance from the pole itself is now about $2^{\circ} 36'$ [grad. 2. 36 circiter]. Having sighted the star against the top of some tower, or against the pinnacle of some other large building, I note when it stands farthest to the east (in the small circle it describes about the pole); I note likewise when it has receded farthest to the west. This is observed from two stations, and the place midway between them, aligned on that same pinnacle or tower, gives with the greatest exactness a very long meridian line.

Once this meridian has been established, the same meridian cannot fail to be known, extended from that same tower or pinnacle right up to the pole itself. At Herk [Hercæ] I have two outstanding ones, because my church raises two towers — the eastern one smaller, the other, the western, larger. Nor am I short of several meridians in private houses and in other places too, so that I lack nothing on this score anywhere.

So it is at meridians of this kind that I observe the arrivals of the stars:

and without any quadrants, without any hesitation, without any fading-out [intermorio] or deception of sight, without any suspicion of error, without motion or fatigue of the body — in the greatest quiet and calm — I obtain the time with the utmost precision.

Moreover, I always add to these sundials [Scioterica], either of lead or of stone, no smaller than a foot, each of which marks the single minutes quite spaciouly. I made them and set them up myself, with all the care I could, so that the time may be revealed by the shadow of the Moon at night (once the ascensional parallaxes [Parallaxibus Ascensionalibus] have been corrected) no less than by the shadow of the Sun by day. Nor am I ever misled by even the slightest amount: at the very same instant [punctifitio] of any phase the sundial also agrees with the culminations, and I can pronounce even on a fair part of the most negligible minute. Compared with this short cut, hunting the altitudes of the stars in that way — as we have already said others do — is a road far too roundabout.

Now, if it should happen that the sky denies us every sight of the stars, and the Moon sheds no light either, then I put my eye to the edge of the sundial and at least sight along it; and the point of its edge, or rim, at which the Moon comes into my eye along the axis I mark at once with lead [molybdenâ] or with red chalk [rubricâ], or else cut with a small knife. In this way the time that has passed can be examined at leisure even long afterwards, after quite a few years.

Sand-glasses [Clepfydræ Arenariæ] also stand by, likewise doing me their service. If nothing else, they faithfully measure every duration; and if there is any slowness or haste in the striking clocks [Horifoniis], they expose it and hand it over, as it were, into my hands for correction, if that is needed.

As for the striking clocks, even if I do not heed them, I nonetheless hear them, since their use is always most convenient: hardly any quarter-hour is struck without some star culminating at the same moment, as either the indicator of the true time or the exposer of a false one. Or, if that culmination does not coincide with the very moment of the sounding stroke, still hardly ever do two, three or four minutes pass before the wish is satisfied.

But there is one thing among these which I noticed only later, and which in the end became the strongest reason for re-examining the earlier observations afresh and — with every illusion [hallacinatione] removed, if any, however slight, had held me in doubt — for establishing and weighing them with the greatest accuracy.

For in this Low Country of ours [Belgio] the north-west wind [Corus] blows for the greater part of the year, and it carries with it from the Ocean sea vapours, clouds and rains in great force and abundance, which it dashes against our lands. As a result the spires [obelisci] of wooden towers, shaken gradually out of their own perpendicular, eventually lean somewhat as well and settle toward the east; and the taller and leaner each one is, the more it suffers this. I found, then, that the smaller turret of my church — slender, with what is as it were a single spire, and that one set on little columns — leans toward the east by about 45'; by that whole amount the stars reach the supposed meridian up there sooner than they reach the truest meridian at the foot of the shaft. The larger tower, which rises in a broader, continuous cone and is not bound together well enough inside with beams, I observe has inclined its axis toward the east even more. Therefore, if I take its very top as my mark, I find that the culminations run ahead of the true time by as much as a degree or more; that is, I had taken the moments of the eclipses to be about 4^m of time later than they were.

So for as long as I suspected nothing of this and hunted the times by the indication of these towers, I always sensed some lurking, hidden illusion, mocking me by three or four minutes however careful I was, and — unless it was the sundials [Scioterica] that made it so — leaving me anxiously perplexed. I could never work out its cause for myself until, astonished, I discovered the thing I had not known. From then on, just as nothing has deceived me there since the year 1638, so also, having wiped away every error retrospectively, I at last attained certainty about the very minutes, and even about considerable fractions of minutes.

Minutes, indeed, and even the very seconds, I have learned to represent to myself quite exactly, with a device always at hand and one I carry with me everywhere. It is Hesiod's book [Greek: Ἔργων καὶ ἡμέρων (Ergōn kai hēmerōn, "of Works and Days")], whose verses I long ago grew used to reciting at thirty to each minute of time, and no fewer, so that each half-line [Hemistichia] of them answers most exactly to a single second. So when the eclipse has begun, I count how many minutes slip by until either some star culminates or a striking clock [Horisonium] is heard; and from there, as though a gate now stood open, I proceed in safety. Nor am I ever deceived or tripped up here in a way that would keep me from proceeding quite calmly, without any hitch. I urge everyone who pursues these observational studies to do the same, and I dare to promise that they will never regret it.

Anyone who wants more laborious and more fastidious methods of measuring times may keep them, for all I care. I begrudge no one his toilsome troubles, so long as I myself can carry out the task I have undertaken very lightly and without troubles. For the benefit, however, of those who will not dislike these things, I add another instrument as well, even more convenient than that one and available to anyone. It is the arm — my own, of my own body — which I use in place of the radius [Radij], while the hand plays the part of the transom

[Trāsuersarij]. For through long practice I have it that my finger, sighted at the end of the outstretched arm, subtends a degree and a half [sesquigradum]; that the palm (that is, four fingers sighted together) takes up a full 6 degrees; that all the fingers spread into a span and sighted at their tips correspond, from thumb to little finger, to 19 degrees, and from index finger to the same little finger show exactly eleven. This holds, of course, for horizontal measurement. For if I raise my hand upward toward the stars, the nearer I bring it to the zenith, the greater the angle the same fingers subtend, because my eye is then that much closer to the fingertips; and (unless I take care) 30 degrees now turn into 34 and 35. On this point too I am equipped with precautions that do not deceive.

With the help of this instrument, just as by day I measure the Sun accurately (and with success, to everyone's astonishment), so that I can declare what hour it is after sunrise, or likewise what hour before sunset, so I can determine no less exactly how far it still stands from setting and how much distance it has already covered since rising; by how many degrees it is short of the meridian (once that has been given) or has already passed it. I know that I have never strayed from the true moment of time by two, or at most three, minutes. Usually — indeed always — I have come out level with the sundials and culminations, the striking clocks, the water-clocks [Clepsydris] and supports of that kind, beyond my own expectation and beyond the scrutiny and belief of those watching.

Different people devise popular measures of time, one after another. It is an ancient practice to reckon hours, half-hours and quarter-hours by the lengths of journeys. In Achilles Tatius, chap. 18, the Chaldeans claim that an hour's journey — the distance a man who is neither running nor strolling, neither old nor a boy, covers comfortably — is a clean thirty stadia [tricena mera stadia]. That is 18000 feet, which is certainly true even today; and I have quite often found that our Belgian hour-leagues [Leucas Belgicas horarias] consist of the same number of feet.

The Provençal leagues [Leucæ Prouinciales], on the other hand, consist precisely of five Roman miles, that is, of 25000 feet. The present-day distances, compared with those recorded in the Itinerary of the Emperor Antoninus [Itinerario Antonini Imperatoris], teach us this most plainly, with one consistent vote. Now I always covered five Provençal leagues in six hours: each league, that is, in 1^h 12^m, which is a thousand Roman paces in about 15^m, a quarter-league in 18^m and a half-league in 36^m — which is the regular pace of an unencumbered traveller there. So in this way too, with the distances between places marked out, I grew used to representing to myself, by the Provençal cannes or fathoms [Cannas seu Orgyas Prouinciales], the points of time — all but the very moments — quite accurately.

It would not be out of place to investigate times by the pulse of the artery as well, if every person, at every age, kept the same unvarying health [si homini, omni ætati omni, valetudo constaret eadem nihil variata] [recte: Si homini omni, per the book's errata]. But since one person has 4000 pulses, another

more and another fewer,⁵ I myself, as a young man in good health in Provence, always had 4200, and from that too I sometimes fetched the times [accersium] — reliable enough, certainly, if I sought them within a quarter-hour; beyond that I chose to attempt nothing.

Some fourteen years ago, and a little more [quod excurrit], another method of measuring times arose: by the oscillations of a hanging weight [per Oscillationes ponderis penduli]. Galileo [Galilæus] was the first to publish it, in his *Dialogues* issued in the Italian language in the year 1630, and he made it virtually certain that *all the oscillations of a solid pendulum, once set in motion, are equal to one another — whether they are large or, as happens, smaller and smaller, until it ceases to move*. And this view began to take hold.

In the year 1631 Mersenne [Mersennus] advised me of this, and what he had put forward in the manner of a riddle he solved in these very words: "*You can count time most exactly with a cord of three feet on which a weight of 8 ounces is hung, for by its swings it marks seconds [secunda minuta]*." Athanasius Kircher [Athanasius Kircherus], on page 450 of his *Magnes* (Cologne edition), says: "*It has been found that a thread of 3 feet and a half measures one second by its vibration*." For my part, with a suspension of 42 Roman feet, I found the oscillatory swings of an iron weight of 52 pounds to number at most [ad summū] 543 per hour, which squares well enough with that ratio of three and a half feet (these matters being reserved for their proper place).

My friend Langren [Langerenus — Michael Florent van Langren] too, who long ago undertook to measure times with iron rods [Rhopalis ferreis] of various lengths and weights, has hunted down, among many other things, the diameter of the Sun as well — and very successfully indeed.

It is not true, however, that all the oscillations of the same suspension are equally long. What is true is that more of them occur in one hour in winter — that is, with the Sun at perigee — than in summer, with the Sun at apogee; again, that semicircular swings take up more time than quadrantal ones; and that the less they are thrown out on either side beyond the perpendicular line, the less delay they also weave in, until they come to rest (for otherwise they would never reach rest at all). Yet if the pendulum is drawn out on either side of its perpendicular line as far as 10 degrees, *it will complete a great many oscillations, and isochronous ones — that is, equally long — for a very long time* [Isochronas, seu æquè diuturnas].

Nor will it be beside the point to set before the eye the numbers to which the decrements correspond, as I have computed them degree by degree.

The table at the head of this page is set as a single sentence: four upright columns of figures, each preceded by a phrase printed turned through 90°. Read across, it runs: "*If, then, the pendulum is drawn out beyond its perpendicular by [90 ... 10] degrees, the oscillatory times will be to one another as [355 ... 320]. In the last 10 degrees [10 ... 1] the ratio of the times will be [3200 ... 3196]*."

⁵the page sets no unit of time for these counts

Si ergo extrahatur pendulum extra suum perpendicularum gradibus [If, then, the pendulum is drawn out beyond its perpendicular by degrees]	Oscillatoria momenta erunt ad inuicem vt [the oscillatory times will be to one another as]	In postremis 10. gradibus [In the last 10 degrees]	erit ratio momentorum. [the ratio of the times will be]
90	355	10	3200
80	347	9	3199
70	340	8	3199
60	335	7	3198
50	330	6	3198
45	328	5	3197 ⁶
40	326	4	3197 ⁷
30	323	3	3196
20	321	2	3196
10	320	1	3196

It is evident, then, that at the bottom of the suspension, over the very short spaces of a few degrees, the oscillations are equal to all perception, and that they can therefore be used quite conveniently for investigating the moments of time in that part of the year in which they have that size.

Let these things, then, be said thus far, in this manner, by way of preface. From them you may understand, eclipse-loving reader [PHILECLIPTICE LECTOR], what care and what circumspection I have always taken that the beginnings, middles and ends of eclipses should be established with certainty for me and for you — that is, how I have striven to prove my diligence to you: a diligence worthy of being excused, if only because it will think it a glory to be surpassed by yours.

It remains for me to disclose in a few words the route by which I have set out to proceed, so that, by means of the eclipses I have presented here, those two prodigious Paradoxes of my *Lampas* [LAMPADIS] may be brought forward into a doctrine to be acknowledged by all mortals, and out of the densest darkness into clear light. This cannot be done without tables, and I am not giving them at present. Yet, so as not to fail altogether the wishes of those who long for them (and, I hope, favour them), I will give, if not the tables themselves, at least the material [Greek: ὕλην (hylēn, "matter, material")] from which they were built; from that same source anyone (who has the leisure) may fabricate his own. Something of the kind may already have been completed by Father Sirmanus [?] of the Society of Jesus [S. I.], a great hope of the doctrine of eclipses, as of the rest of mathematics, who before he left Belgium for China [in Sinas] visited my house and library, honoured it as my guest, and took away the whole plan [Ideam] of my tables as a parting gift [Apophoretum]. I have shared this ungrudgingly not with him alone but long since with others too, among them Fathers Chifflet [Chiffletio] and Bucherius [Gilles Boucher] of the same Society — reckoning that I owed at least this to that most learned

⁶a small mark like a semicolon follows the figure

⁷a small mark like a colon follows the figure

Society, whether as a task set or as a pupil's fee [seu Pensum seu Minerual], for the apprenticeship [Tyrocinij] I served under it at Tournai [Tornaci]. I was aware, too, that my years are now gathered in [ætatem mihi iam esse in collecto], and that the hope of finishing the work is a steep one: for I am both pulled away by pastoral cares and, while defending my household obligations, I wrestle time and again with dishonest men. And, finally, I am toiling through this Atlantean labour [ATLANTICVM laborem] alone — without a Hercules, without a Theseus, by myself, that is, without any amanuensis.

That greatest of heroines, the divine Isabella Clara Eugenia [ISABELLA CLARA EVGENIA], had begun to unfold toward me the candour of her divine heart: while I was absent and thinking of nothing of the kind — indeed, perhaps at that very time lying gravely ill and already a candidate for death — she enriched me with a canonry, for the time being at Condé [Canonicatu, interim Condatensi], and with honours. But behold: on the very threshold of my fortune she left the earth, which was unworthy of her, and shut off from me the sight of heaven. From then on, as one misfortune followed another, raging in private and in public, I so far failed myself that my friends Petavius [Petavius; Denis Pétau], Gassendi [Gassendus] and Mersenne [Mersennus] believed me dead — a man they saw living to no public good.

At last a better lot looked upon me. So that I should not lack a supply of books, nor be worn down by ruinous expenses away from home while I am occupied with publishing my works, it opened to me the doors of friends. At Brussels, those of magnates and illustrious men: of the Count of Bucquoy [BVCQVOI Comitibus], and above all of my host, the Marquis de Torres [MARCHIONIS DE TORRES]. Then of the great President Roose [Magni Præsidis ROSÆ], my taskmaster [Greek: ἔργοδιώκτης (ergodiōktēs, "of the taskmaster")]; of Chancellor Boischoët [Cancellarij BOISCHOTII], of Treasurer Kinschoët [The-saurarij KINSCHOTII]; of the councillors Malinæus, Burgundius, Deckherus and Stockmannus [Consiliariorū MALINÆI, BVRGVNDII, DECKHERI, STOCKMANNI]; but most of all of the Chifflets [CHIFFLETIORVM], to whom I owe my whole self. At Antwerp, after the Count of Sastago [SASTAGI COMITEM], governor of the citadel [Arcis Præfectū], when I name Edelherius and Gevaerts [EDELHERIVM & GEVARTIVM], I sum up humanity and learning in brief.

With these men as my backers, then, if I do not yet bring out the tables, I at least set forth their plan [Ideam]. Their kindness, and your goodness, reader, as you interpret me, will shortly — God willing [CVM BONO DEO] — await those tables too, entire.

THE PLAN OF THE ATLANTIC TABLES [TABVLARVM ATLANTICARVM IDEA.]

THEORY OF THE SUN [THEORIA SOLIS.]

Thirty-three [33] tropical years of the Sun [Anni Solis Tropici] contain 12053 days, quite precisely. The year therefore has, in days and decimal parts of a day [partes denarias], 365.24242424 and so on to infinity — a repeating pair of digits [Digrammum] — which are $365^d 5^h 49^m 5^s 27''' 16''''^8$, and so on to infinity.

The apogee of the Sun completes a tropical circuit [orbem Tropicum] in 20864 tropical years, 20863 of its own.

The precession of the equinoxes against the order of the signs [in Antecedentia] — or the motion of the fixed stars in the order of the signs [in Consequentia] — completes a tropical circuit in 25520 tropical years: 25519 of its own.

The restitution [Apocatastasis] of the obliquity of the Sun oscillates in no fewer than 9748 years.

The daily motions, therefore, are [DIVRNI ERGO MOTVS SVNT]

In degrees of the Sun and decimal parts of a degree:

Motion	Degrees and decimal parts
Tropical [Tropici.]	0.985646726956
Eccentric [Excentrici.]	0.985599485453
Sidereal [Siderei.]	0.985608104435

Which are, in sexagesimal parts:

Motion	Deg.	'	"	'''	''''	'''''	''''''
Tropical [Tropici.]	0	59	8	19	41	34	55
Eccentric [Excentrici.]	0	59	8	9	29	19	53
Sidereal [Siderei.]	0	56 [recte: 59]	8	11	21	2	0

The eccentricity of the Sun is 174524 units [partium] of which the semidiameter of the eccentric is 10000000 — which is its mean distance from the Earth: 229 semidiameters of the Sun, 14656 of the Earth [Telluris].

The distance of the Sun from the Earth's centre is therefore, in such units: greatest 10174524, least 9825476.

The greatest prosthaphaeresis of the Sun is $2^\circ 0' 0''$ precisely, always constant and invariable.

	At apogee [Apogæi.]	At mean distance [Medij.]	At perigee [Perigæi.]
Of the Sun [SOLIS]			
The diameter is [Diametrus est]	29' 30"	30' 0"	30' 33"
Semidiameter [Semidiametrus]	14' 45"	15' 0"	15' 17"

⁸ 27 and 16 stand in the third and fourth sexagesimal places of time.

Of the Sun [SOLIS]	At apogee [Apogæi.]	At mean distance [Medij.]	At perigee [Perigæi.]
Greatest parallax [Maxima Parallaxis]	0' 14"	0' 14"	0' 14"

LET US FIX THE SOLAR EPOCH [FIGAMVS EPOCHAM SOLAREM.]

In the course of the year 1600 of the Christian era [Anno Christianæ Epochæ 1600 Labente]; at Atlantic midnight [Ad mediam noctem Atlanticam]; between the end of February and the beginning of March in the Gregorian year; five days from the intercalated leap day [ab Intercalato Bissexto] —
the Sun was distant [ABFVIT SOL]

From ☿	From the apogee
339° 2' 51"	243° 19' 57"

Ten days later, at the beginning of the Julian March [Ineunte Martio Juliano]:

From ☿	From the apogee
348° 54' 19"	253° 11' 20"

THE PLAN OF THE LUNAR TABLES [IDEA TABVLARVM LVNARIVM]

THE ECLIPTIC [ECLIPTICA.]

Twenty-seven thousand [27000] lunar months contain 797326 days precisely. The monthly period of one lunation [Menstruum ... tempus vnus Lunationis] therefore has, in days and decimal parts of a day, 29.530592592592 and so on to infinity, a repeating group of three digits [Trigrammon].

Which make up:

Days	Hours	Min.	Sec.	Tert.
29	12	44	3	12

— most precisely [præcisissimè]. Parsing notes: a duration running finer than seconds keeps the page's columns ("Dies Horas Min. Sec. Tert."); all are units of time.

Meanwhile the Sun, in its mean motion in the zodiac, completes, in degrees and decimal parts of a degree, 29.106731934; or

Deg.	'	"	'''	''''	'''''
29	6	24	14	5	52

— very nearly [ferme].

In the same interval the Sun also moves away from its apogee, in degrees and decimal parts of a degree, 29.105336864; that is,

Deg.	'	"	'''	''''	'''''
29	6	19	12	45	45

The restitution [Apocatastasis] of the lunar anomalies holds 18038 eccentric circuits [Orbes Excentricos] in 16831 months. The difference is 1207 circuits. The monthly anomaly therefore completes, beyond a whole circuit, in degrees and decimal parts of a degree, 25.81664815, nearly [fere]; or

Deg.	'	"	'''
25	48	59	56

— quite precisely [satis præcisè].⁹

The restitution of the latitudes, counted from the head of the Dragon [à Capite Draconis], holds 7477 draconitic circuits [Orbes Draconticos] in 6890 months. The difference is 587 circuits. The monthly lunar latitude therefore has, in degrees and decimal parts of a degree, 30.67053704, very nearly; or

Deg.	'	"	'''
30	40	13	56

— quite precisely.

The greatest prosthaphaeresis of the Moon in the syzygies [in Copulis] — that is, in conjunctions and oppositions — is 5° 0' 0", most precisely.

The greatest latitude of the Moon in the syzygies — that is, the angle of intersection of the Moon's path [Viæ Lunaris] and the ecliptic — is 5° 0' 0", most precisely.

The daily motions, therefore, are:

Daily motion	Deg.	'	"	'''	''''	'''''	''''''
Moon from the Sun [Lunæ à Sole]	12	11	26	41	28	33	22, nearly [ferè]
Moon from the apogee [Lunæ ab Apogeo]	13	3	53	56	1	5	38
Moon from the Dragon [Lunæ à Dracon.]	13	13	45	39	32	7	36

⁹the three figures 25, 48 and 59 in this row stand in heavier ink than the rest of the page, and the degrees figure is blotted; its two sorts are still visible under the blot.

THE ECCENTRICITY OF THE MOON [Excentricitas Lunæ] is exactly [omnino] 654465 parts, of which the semidiameter of the eccentric is 10000000; and it is always constant and invariable.

The Moon's mean distance from the centre of the Earth is most precisely 60 semidiameters of the Earth [Semidiametros Telluris]. Now take the Earth's semidiameter as 1000 hourly leagues [Leucarum horarium] — which are likewise Persian parasangs and Egyptian schoeni [Schoeni Ægyptij] of thirty stadia each. The lunar distances and their parallaxes will then be as follows:

The Moon is distant [Luna distat]	Parts [Partes]	Leagues [Leucas]	Parallax [Parallaxis est]	Semidiam.
At apogee [Apogæa]	10654465	63,927	53' 46"	14' 20"
Mean [Media]	10000000	60,000	57' 18"	15' 17"
At perigee [Perigæa]	9345535	56,073	61' 18"	16' 21"

The Moon's semidiameter, however, is greater seen at the zenith [in vertice] than at the horizon, and this must necessarily be taken into account in solar eclipses. There, then, the semidiameters will be 14' 35", 15' 32" and 16' 39".

So let us also fix the LUNAR EPOCH [Lunarem Epocham]. In the year 1600, at Atlantic midnight between the end of February and the beginning of March in the Gregorian calendar, five days after the intercalated bissextile day, the Moon in its mean motion stood

- from the Sun: 192° 8' 0"
- from its apogee: 338° 3' 6"
- from the head of the Dragon [A Capite Draconis]: 232° 45' 10".

The epacts [Epactæ] were:

Days	Hours	Min.	Sec.	Tert.
15	18	25	13	36

THEREFORE THE NEXT MEAN NEW MOON [Ergo Novilunium Sequens Medium] fell after Atlantic midnight, when there had elapsed, in the current Gregorian March:

Days	Hours	Min.	Sec.	Tert.
13	18	28	49	36

At that moment, in mean motion, the values were:

- Place of the Sun from ♑ [Locus Solis ab ♑ gr.]: 352° 37' 12"
- Anomaly of the Sun [Anomalía Solis]: 256° 54' 16"
- Anomaly of the Moon [Anomalía Lunæ]: 157° 57' 25"
- Latitude from the head of the Dragon [Latitudo à Cap. Drac.]: 54° 55' 16"

With this term fixed, it is easy to gather the times both backward and forward and to establish EPOCHS [Epochasque]. Our Tables have done this, starting 6000 years and 10 months before the Christian epoch, likewise from Atlantic midnight at the end of a bissextile February and the beginning of March, in the Julian calendar.

There remains the definition of the Earth's shadow [Vmbrae Terrenae], which must be the first concern in these matters. We shall obtain it most easily as follows:

Add the parallaxes of the Sun and the Moon; then subtract the Sun's half-diameter [semissem Solis]: so the shadow is found.

Let the Sun be at apogee and the Moon likewise at apogee. The parallax of the Sun is 0' 14", the parallax of the Moon 53' 46". Together these make 54' 0". Subtracting the Sun's semidiameter, 14' 45", there remain 39' 15" for the semidiameter of the shadow there, in the Moon's passage [in transitu Lunae].

Let the Sun be at perigee, and the Moon likewise at perigee. The parallaxes are: of the Sun 0' 14", of the Moon 61' 32". Subtracting the Sun's semidiameter, 15' 17", there remain 46' 15" for the semidiameter of the shadow there.¹⁰

In the same way the computation lies ready to hand for each degree of the lunar and solar anomaly; for that is why I noted the parallaxes [Paraxallaxes] [recte: Parallaxes] and semidiameters [Semidiatrosque] [recte: Semidiametrosque] against each of those degrees, for this use. And of this in its place.

Now let us also set out the brief equations of the Sun and the Moon [Breues Solis & Lunae Aequationes], which are the foundation of this whole disputation, so that the oscillatory motion of the prosthaphaereses [Oscillatorius Prosthaphæreseōn motus] may at least be sketched.

SOLAR EQUATIONS [Solares Aequationes]

Degrees of anomaly, descending [Gradus Anomaliae desc.]	Prosthaphaereses to be subtracted [Prosthaphæses Substrahendæ]	Daily motion [Diurnus Motus]	Hourly motion [Horarius Motus]	Semidiameter [Semidiametris]	Degrees of anomaly, ascending [Gradus Anomal. Ascen.]
0	0° 0' 0"	57' 7"	2' 23"	14' 45"	360
10	0° 20' 24"	57' 9"	2' 23"	14' 45"	350
20	0° 40' 13"	57' 15"	2' 23"	14' 46"	340
30	0° 58' 53"	57' 23"	2' 24"	14' 47"	330
40	1° 15' 51"	57' 30"	2' 24"	14' 48"	320
50	1° 30' 39"	57' 49"	2' 24"	14' 50"	310
60	1° 42' 46"	58' 6"	2' 25"	14' 52"	300
70	1° 51' 54"	58' 25"	2' 26"	14' 54"	290
80	1° 57' 42"	58' 45"	2' 27"	14' 57"	280
90	1° 59' 59"	59' 8"	2' 28"	15' 0"	270

¹⁰the page gives the Moon's parallax here as 61' 32", where the table on the preceding page has 61' 18"; 61' 32" is the sum of the two parallaxes (61' 18" + 0' 14"), and the stated remainder follows from it (61' 32" - 15' 17" = 46' 15"). Figures as printed.

Degrees of anomaly, descending [Gradus Anomaliae desc.]	Prosthaphaereses to be subtracted [Prostaphæses Subtrahendæ]	Daily motion [Diurnus Motus]	Hourly motion [Horarius Motus]	Semidi- ameter [Semidi- ametrus]	Degrees of anomaly, ascending [Gradus Anomal. Ascen.]
100	1° 58' 36"	59' 28"	2' 29"	15' 3"	260
110	1° 53' 36"	59' 50"	2' 30"	15' 6"	250
120	1° 45' 3"	60' 11"	2' 31"	15' 8"	240
130	1° 33' 13"	60' 28"	2' 31"	15' 10"	230
140	1° 18' 24"	60' 44"	2' 32"	15' 12"	220
150	1° 1' 8"	60' 58"	2' 32"	15' 13"	210
160	0° 41' 54"	61' 7"	2' 33"	15' 14"	200
170	0° 21' 17"	61' 12"	2' 33"	15' 16"	190
180	0° 0' 0"	61' 15"	2' 33"	15' 17"	180
	Prosthaphaereses to be added [Addendæ]				

Parallax of the Sun, at apogee and at perigee alike, is 14", and always the same, without perceptible difference.

LUNAR EQUATIONS [LVNARES ÆQVATIONES]

De- grees of anomaly [Gradus Anomal.]	Prosthaphaereses at the conjunctions [Prostaphærefes in Anomal.]	Hourly: divisor, Moon from Sun [Horarius: Diuiſor ☽ à Sole] (m f)	Hourly: motion of the Moon from ☾ [Horarius: Motus ☾ ab ☾] (m f)	Horizon- tal parallaxes [Horizon- tales: Parallaxes] (m f)	Horizontal semidiam- eter [Horizon- tales: Semidi- amet.] (m f)	(Degrees of ascending anomaly)
	To be subtracted, in degrees of anomaly descending toward perigee [Subtrahenda in gradibus Anomaliae descendentibus ad Perigæum]					
0	0° 0' 0"	27' 38"	29' 30"	53' 46"	14' 20"	360
10	0° 52' 6"	27' 40"	29' 34"	53' 50"	14' 21"	350
20	1° 42' 36"	27' 48"	29' 44"	53' 59"	14' 24"	340
30	2° 30' 0"	28' 1"	30' 2"	54' 13"	14' 28"	330
40	3° 12' 50"	28' 18"	30' 26"	54' 33"	14' 33"	320
50	3° 49' 49"	28' 39"	30' 56"	54' 59"	14' 40"	310
60	4° 19' 48"	29' 3"	31' 31"	55' 29"	14' 48"	300
70	4° 41' 54"	29' 30"	32' 10"	56' 2"	14' 57"	290
80	4° 55' 26"	29' 59"	32' 53"	56' 39"	15' 7"	280
90	5° 0' 0"	30' 29"	33' 37"	57' 18"	15' 17"	270
100	4° 55' 26"	30' 58"	34' 22"	57' 57"	15' 27"	260
110	4° 41' 54"	31' 27"	35' 7"	58' 36"	15' 37"	250
120	4° 19' 48"	31' 54"	35' 49"	59' 14"	15' 47"	240
130	3° 49' 49"	32' 19"	36' 28"	59' 49"	15' 57"	230
140	3° 12' 50"	32' 40"	37' 2"	60' 19"	16' 5"	220
150	2° 30' 0"	32' 57"	37' 30"	60' 44"	16' 12"	210

De-grees of Prosthaphæreses at the anomaly conjunctions [Gradus [Prosthaphærefes in Anomal.]copulis] (gr. m f)		Hourly: divisor, Moon from Sun [Horarius: Diuifor ☽ à Sole] (m f)	Hourly: motion of the Moon from ☿ [Horarius: Motus ☿ ab ☿] (m f)	Horizon- tal parallaxes [Horizon- tales: Parallaxes] (m f)	Horizontal semidiam- eter [Horizon- tales: Semidi- amet.] (m f)	(Degrees of ascending anomaly)
160	1° 42' 36"	33' 9"	37' 51"	61' 3"	16' 17"	200
170	0° 52' 6"	33' 17"	38' 3"	61' 14"	16' 20"	190
180	0° 0' 0"	33' 20"	38' 8"	61' 18"	16' 21"	180
To be added, in degrees of anomaly ascending toward apogee [Addenda in gradibus Anomalix ascendentibus ad Apogæum]						Degrees of ascending anomaly [Grad. Anomalix Ascenden- tis.]

I have not added the vertical increments of the lunar semidiameter here, because I am deferring solar eclipses and confining myself for the present to lunar ones, for the reasons I have given.

To show the use of these brief and modest tables [Breuium harum & qualium qualium Tabularum vfus], as a sample of the larger and fuller ones, I take my Climacteric eclipse of Antwerp [Eclipsin meam illam Climactericam Antuerpi- ensem] of the year 1643, observed so carefully and diligently that I do not expect anything could be added to that diligence; and I summon it to my Atlantic calculations as follows.

FIRST [PRIMO]

At the vernal new moon of the secular year 1600, reckoned by the Gregorian calendar, we have already fixed above the time and the configuration of the heavens, as follows:

Days, hours [Dies. Hor.,///]	Place of the Sun [Locus *.]	Anomaly of the Sun [Anomal. *]	Anomaly of the Moon [Anomal. ☾]	From the Dragon [A Dracon.]
13 ^d 18 ^h 28 ^m 50 ^s	352° 37' 12"	256° 54' 16"	157° 57' 25"	54° 55' 16"

Our eclipse of Antwerp occurred 43 years after that, and six months and something over. In my Secular Canon [Canone meo Sæculari], at the year 43, a new moon is entered with these days and motions:

5^d 6^h 36^m 22^s | 4° 46' 53" | 4° 2' 21" | 54° 27' 24" | 116° 43' 33"

I add these to the values above, and so make up the sum of all:

19^d 1^h 5^m 12^s | 357° 24' 5" | 260° 56' 37" | 212° 24' 49" | 171° 38' 49"

I declare, therefore, that in this year of ours, 1643, the mean new moon which the calculation first offers me after the end of the Gregorian February occurred when there had elapsed 19 days, 1 hour, 5 minutes, 12 seconds after Atlantic midnight.

Now in the Canon of New and Full Moons [Canone Nouiluniorum ac Pleniluniorum], at the seventh full moon, these days and celestial motions are entered:

$191^d 22^h 46^m 21^s \mid 189^\circ 11' 38'' \mid 189^\circ 11' 5'' \mid 347^\circ 48' 30'' \mid 19^\circ 21' 31''$

These, then, I add to the nearest numbers of the new moon found. The sum is:

$210^d 23^h 51^m 33^s \mid 186^\circ 35' 43'' \mid 90^\circ 7' 42'' \mid 200^\circ 13' 19'' \mid 191^\circ 0' 10''$

Therefore, when there had elapsed 210 days after Atlantic midnight at the close of February — that is, when the days of the month of September had run to 26, and $23^h 51^m 33^s$ besides, very nearly — there occurred the mean full moon [No-luilunium medium] [recte: Plenilunium medium, per the book's errata].

At that moment the mean place of the Sun was likewise at $186^\circ 35' 43''$ from the vernal section φ — that is, it was in $6^\circ 35' 43''$ $\underline{\Omega}$. Its anomaly was $90^\circ 7' 42''$; the anomaly of the Moon was $200^\circ 13' 19''$. Finally, both centres, of the shadow and of the Moon, stood $191^\circ 0' 10''$ from the head Ω [Cap. Ω .] — that is, $11^\circ 0' 10''$ from the tail of the Dragon. Because of the very great ease of my Tables, these values were gathered in this way by a very short abridgement of calculation.

SECOND [SECVNDO]

With the moment of the mean ecliptic conjunction [Mediæ Copulæ Eclipticæ] now given, in order to arrive at the true conjunction and its time, I first of all look up the prosthaphæreses of the given anomalies, of the Sun as well as of the Moon, taking them from the Tables. I note each one at a line drawn midway between the two anomalies, with a short stroke either to the right or to the left, according as they are setting [occiduæ] — that is, subtractive — or rising [ortiuæ] — that is, additive. To large prosthaphæreses I give a somewhat longer line, to smaller ones a somewhat shorter one, at least roughly proportional to their size. And because the Sun is higher than the Moon, I draw the stroke for the solar prosthaphæresis somewhat higher than the lunar one. In this way, as if in a rough sketch [Iconifimo quodam rudi], I set out eye-catching signs [oclifera] that show at once, without hesitation or risk of error, whether one body is more easterly or more westerly [Occidetalius] than the other — that is, whether the Moon has not yet reached the place of the Sun, or the middle of the shadow, or has passed it; and hence whether something must be added to or subtracted from the mean time already known. An example:

Our anomalies were [Anomalix nostræ fuerunt]	$90^\circ 7' 42''$	$200^\circ 13' 19''$
Their prosthaphæreses are [Prosthaphærefes earum sunt]	$1^\circ 59' 59''$	$1^\circ 43' 42''$
I draw the prosthaphæretic signs [Signa præstaphæretica pingo]	»—	—*

These show that the Moon was more easterly than the Sun, and that the true conjunction therefore occurred much earlier — by the whole amount, namely,

of $1^{\circ} 43' 41''$ and also $1^{\circ} 59' 59''$, that is, $3^{\circ} 43' 40''$. For determining this time, I again set out a short method.

THIRD [TERTIO]

A lunar anomaly of $200^{\circ} 13'$ has, noted against it in the Table of Lunar Equations, an hourly divisor [Diuiforem horarium] of $33' 9''$. By this I divide those $3^{\circ} 43' 40''$, and so I find, finally, roughly $6^h 44^m 49^s$. I say, therefore, that the true conjunction of the centres of the Moon and of the shadow [veram Copulam Centrorum Lunæ & Vmbræ] occurred about $6^h 45^m$ before that moment — or at least very nearly so, perhaps within a minute or two either way. To fix this time more exactly from these hours, I equate the anomalies with full precision [exactissimas Anomalias peræquo].

FOURTH [QVARTO]

In $6^h 45^m$ the anomaly of the Sun changes by $16' 38''$, and the anomaly of the Moon by $3^{\circ} 40' 28''$ at most. Before those hours and minutes, therefore, the true and equated [coæquata] anomaly of the Sun was $89^{\circ} 51' 2''$, and the equated anomaly of the Moon $196^{\circ} 32' 50''$. Their prosthaphaereses are $1^{\circ} 59' 58''$ and $1^{\circ} 25' 26''$, which together make $3^{\circ} 25' 24''$, with this sketch [Iconifmo]:

Diagram. A small prosthaphaeretic sketch set at the right of the line, between two short vertical bars. The upper horizontal stroke runs from the left bar and ends at the sign of the Sun; below it, slightly lower, the sign of the Moon stands at the left with a horizontal stroke running from it to the right bar.

- ☉ (upper stroke, right end): the Sun
- ☾ (lower stroke, left end): the Moon

So the line of the Moon's mean motion stood that many degrees away from the line of the Sun's mean motion, against the order of the signs [in Antecedentia], when the true conjunction took place. But the Moon covers exactly that interval, before or after the Sun, by its mean motion in precisely $6^h 44^m 23^s$. This, then, is at last the time sought, determined with the greatest exactness, by which the true conjunction preceded the mean one: it differs by scarcely the least amount from the time found by that simple divisor — an admirable stroke of good fortune.

I say, therefore, that on the Atlantic meridian [in Meridiano Atlantico] the true conjunction fell after 26 complete days of the month of September and $17^h 7^m 10^s$, and that at that moment both centres, of the shadow and of the Moon, stood away from the node of the Dragon by just that number of degrees.

FIFTH [QVINTO]

The greatest obscuration, or middle of the eclipse [Medium Eclipticū], always occurs at that point of the lunar orbit on which the perpendicular from the centre of the shadow falls. That is, the place and moment of the greatest defect always lie nearer to the node of the Dragon than the centre of the shadow itself does. Up to now, however, we have obtained from the calculation the moment at which both centres are equally distant. It is clear, therefore, that some reduction [Reductione aliquâ] of the Moon to that point of its orbit is

needed. We shall obtain it if we first know how far the centre of the shadow stood from that node at that same hour, $17^h 7^m 10^s$.

At that mean time, $23^h 51^m 33^s$, it stood $191^\circ 0' 10''$ away. Therefore, $6^h 44^m 23^s$ before that time — the hours we found — it was further back by $0^\circ 17' 30''$. That is, at that hour, $17^h 7^m 10^s$, the centre stood $190^\circ 42' 40''$ away. But the prosthaphaeresis of the Sun, and of the shadow, is subtractive [ablatiua]: $1^\circ 25' 26''$. The true distance of the centre of the shadow from the head of the Dragon is therefore $189^\circ 17' 14''$.

That is, this centre stood $9^\circ 17' 14''$ from the nearest node, which they call the tail of the Dragon. The perpendicular let fall from there onto the path, or orbit, of the Moon falls on a point $9^\circ 15' 7''$ from the node. So the reduction comes to $2' 7''$: by that amount the Moon was nearer the node than the centre of the shadow at the very moment of greatest defect, and the greatest defect accordingly occurred that much earlier here.

SIXTH [SEXTO]

Now, to know how much time the Moon spent in running through these $2' 7''$ of reduction: the equated [coæquata] anomaly of the Moon, $196^\circ 32' 50''$, has noted against it an hourly motion from ♑ (that is, from a tropical point [puncto fcilicet aliquo Tropico]) of $37' 56''$, while the anomaly of the Sun, 90° , shows an hourly motion of the Sun, likewise from ♑, of $2' 28''$. It is clear, therefore, that here the Moon is faster than the Sun itself, and than the centre of the shadow, by $35' 28''$ an hour. If, then, the Moon proceeds ahead of the Sun by that many minutes within one hour, it will surely complete those $2' 7''$ of reduction in the space of $3^m 35^s$ of an hour, and by that much the greatest defect preceded the computed time [suppu tatum]. When this is taken from those $17^h 7^m 10^s$, there remains the true time of greatest obscuration and middle of the eclipse [Medium Eclipticum]: after 26 days of September, at $17^h 3^m 35^s$ after Atlantic midnight [post Mediam noctem Atlanticam]. The whole difference between the mean and the true opposition is therefore $6^h 47^m 58^s$.

SEVENTH [SEPTIMO]

To reduce the time found on the Atlantic meridian to the meridian of Antwerp [Meridianum Antuerpiensem], the catalogue of places we have already set out shows that $1^h 48^m 40^s$ must be added. At Antwerp, therefore, the middle of this eclipse falls at $18^h 52^m 15^s$ from midnight, with the utmost precision.

EIGHTH [OCTAVO]

Now, to obtain the latitude of the Moon, I take up again that difference between the mean and the true opposition, $6^h 48^m$, and I find that in the meantime the Sun, or the centre of the shadow, moves away from the nodes by $17' 40''$, which are to be subtracted. The prosthaphaeresis found earlier, $1^\circ 59' 58''$, was likewise to be subtracted. When these are subtracted from those $191^\circ 0' 10''$, the true distance of the centre of the shadow from the node remains,

$189^{\circ} 42' 32''$ in all¹¹. The perpendicular let fall from there onto the orbit of the Moon is therefore $45' 22''$, and that is the latitude of the Moon from the ecliptic at the time of greatest defect.

NINTH [NONO]

To know how much of the Moon is immersed in the shadow there, I first determine the shadow itself, by the method already given. I join the parallax of the Sun [Parallaxin Solis], $0' 14''$, to the parallax of the Moon, $61' 8''$, and obtain the sum $61' 22''$. From this I subtract the semidiameter of the Sun, $15' 0''$; what remains: $46' 22''$, which is the semidiameter of the shadow. But the centre of the Moon has already been found to stand $45' 22''$ from the centre of the shadow. It is therefore plain that more than the semidiameter of the Moon was immersed in the shadow, and so I now go on to the ecliptic digits [digitos Eclipticos].

TENTH [DECIMO]

To determine the ecliptic digits, I take the semidiameter of the Moon, in minutes $16' 18''$ [as printed: "minut. (1)6'.18'."]¹², and that of the shadow, $46' 22''$. The sum is $62' 40''$. From it I take away the latitude just obtained, $45' 22''$, and there remain $17' 18''$ for the deficient part of the lunar disc. Now the Moon's own semidiameter, $16' 18''$, makes up 6 digits; so that deficient part of $17' 18''$ yields 6 digits with $22'$ — and this was the greatest magnitude of this eclipse on the disc of the Moon. On the boss [in vmbone], however (where the shadow is by so much the larger), the digits were 6 with 28 minutes; and on account of our parallactic boss of the Moon [vmbonem Lunæ parallaxicum nostrum], the digits were over six and a half — exactly as many as in fact appeared to us.

ELEVENTH [VNDECIMO]

Finally, to calculate the whole semiduration as well: given the sum of the semidiameters already collected, $62' 40''$, I extract the corresponding antilogarithm [Antilogarithmum], 16616. From it I subtract the antilogarithm of the latitude, likewise given, $45' 22''$, which is 8708. There remains the antilogarithm [Antilegarithmus] for the line of incidence [lineâ incidentiæ], 7908, which is $43' 13''$. This is to be divided by the hourly motion of the Moon from the Sun obtained earlier, $35' 28''$. It then gives, at last, the semiduration: $1^h 13^m 6^s$ — so that the whole eclipse lasted $2^h 26^m 12^s$.

TWELFTH [DVODECIMO]

From this it is concluded that this whole eclipse went as follows.

		In Atlantico [on the Atlantic meridian]	Parifiis [at Paris]	Antuerpiæ [at Antwerp]	Louanij [at Louvain]
Initium [Beginning]	Hor.	$15^h 50^m 30^s$	$17^h 26^m 6^s$	$17^h 39^m 10^s$	$17^h 41^m 30^s$

¹¹so printed; the three values given just before ($191^{\circ} 0' 10''$, less $17' 40''$ and $1^{\circ} 59' 58''$) leave $188^{\circ} 42' 32''$

¹²the 1 is barely inked on the leaf, hence "(1)" in the bracket.

		In Atlantico [on the Atlantic meridian]	Parifiis [at Paris]	Antuerpiæ [at Antwerp]	Louanij [at Louvain]
Medium [Middle]	Hor.	17 ^h 3 ^m 35 ^s	18 ^h 39 ^m 11 ^s	18 ^h 52 ^m 15 ^s	18 ^h 54 ^m 35 ^s
Finis [End]	Hor.	18 ^h 16 ^m 40 ^s	19 ^h 52 ^m 16 ^s	20 ^h 5 ^m 20 ^s	20 ^h 7 ^m 40 ^s

How exactly these values agree with the observations we will show in the proper place, where we give an account of them. Meanwhile let it be noted here that the eclipse ended at Antwerp with the very stroke of the eighth hour, and that at the same moment the shadow on Edelheer's sundial [Scioterico Edelherij] marked the eighth. The ascensional parallax of the Moon [Lunæ Parallaxis Ascensionalis] was at most 37', and its distance from the centre of the shadow 61' 40" — that is, ascensional, about 55'. The Moon, then, was marking on the sundial six minutes fewer than the true time required. So when it marked 8^h 0^m, it was in reality 8^h 6^m; and already about half a minute earlier, before the warning chime [ante prætinnium], at quite plainly 8^h 5^m 30^s, the limb of the Moon was pronounced clear. So great and so exact was the agreement of the calculation with the sky that everyone exclaimed it was as much as could be promised by any mortal.

Let this, then, stand as a specimen of the Atlantic Tables.

Now at last let us bring the OBSERVATIONS of our century to the test of their rules, so that they may teach us how certain those two secret propositions of my *Lampas* [DVÆ LAMPADIS ARCANÆ Propositiones] are — propositions to be established from experiments and from nowhere else.

I had indeed wanted to omit the observations made before this century of 1600 [ante hoc sæculum 1600], because I had found that much of doubtful reliability lies hidden in them. Yet those of Tycho Brahe [TYCHONIS BRAHE] — a most noble man and, by everyone's admission, the Atlas of our century [sæculi nostri ATLANTIS] — have so far been held to be the most certain, both for the number of his instruments and for their size, as costly as it was elaborate. It therefore seemed right to sample them as well, so that we should not seem to have neglected what we cannot be ignorant of. Since, then, he presents us with eclipses of the Moon to the number of twenty-one, and of the Sun nine — thirty in all — on which he built his tables, we shall call these to examination too. We shall do so, however, only far enough to understand that the great man indulged those same tables of his rather too much, and more than once did violence to the observations, so that he could defend his hypotheses, despairing of more perfect ones.

It had indeed been my plan to bring forward the lunar eclipses alone and leave out the solar ones. That is exactly what both the founder of the Frisian Tables [Frificarum Tabularum conditor] and Tycho's successor Longomontanus [Longimontanus] did; moreover, the lunar eclipses alone suffice to establish those two theorems; and finally, in solar eclipses there is a single, perpetual entanglement of parallaxes [parallaxium implicatio]. Because of these parallaxes,

solar eclipses cannot serve as a first principle, nor be handled by a simple examination, since they themselves need other and more laborious principles. Yet even a mere passing mention of them will remind us of many things that will be of great use later, in their proper place; and at the same time, this chronological order is the one Pétau [Petavius] followed in his expositions [Exegetibus], and others too.

We too shall measure out the heavens under these leaders.

Let us therefore sample what he gave us in the *Progymnasmata* [Progymnasmatis] [recte: Progymnasmatis, per the book's errata].

FIRST ECLIPSE OF THE SUN [ECLIPSIS SOLIS PRIMA] In the year 1567, of 6 digits 20' [Anno 1567. digitorum 6.20']

For Tycho it is recorded on April 9, at 5^h 50^m, at Hven [Huennæ]. Kepler [Kepplerus] describes it in these words (*Optics*, p. 297 [Opt. pag. 297]): "*Tycho, in a letter to Christoph Clavius [Clavius], says that as a young man (he was then only 20 years old) he observed at Rostock [Rostochij], on the shore of the Baltic Sea, at virtually noon itself, not quite 7 digits. In the Progymnasmata he gives the hour and the very point of noon, 12^h 0^m 0^s exactly, with 6 digits 29' — as much as his calculation also yields. In another sheet, however, I found the hour 11^h 0^m, 9 digits 0'.*"

This beginning of the Tychonic eclipses is an omen for those that follow, and as it were a herm pointing out the way [velut Herma viam indicans] that leads to all the others. But that way, rough at once with many sharp stones and winding with many turns, confronts us with a labyrinth [Labyinthum]. For both in the magnitude, the digits are shown now as 6 digits 20', now as a full 9 [modò ostentantur 6.20. modo 9 toti]; and in the time, now only the eleventh hour is given, now noon itself. Finally the calculation, too, comes onto the stage — the one, that is, to untie this whole knot [totius nodi huius vindex], and, I should be surprised if not, the others as well. Let us therefore go forward under this omen (may it turn out well), mindful that we shall stumble now and then over other rough patches too, since we have tripped at the very threshold.

Meanwhile, if this is worth the trouble: my Atlantic calculation [calculus meus Atlanticus] gives this middle, at Hven [Huennæ], reduced to the ecliptic, at 11^h 12^m [horā 11. 12/]. But because of the tangled vexations of the parallaxes [Parallaxium implicata fastidia], these matters are reserved for another place.

FIRST TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA I.]

In the year 1573, on December 8, the Moon was totally eclipsed. Tycho fixes the middle time of the eclipse [deliquij] at Hven at 8^h 3^m after noon [hor. 8. 3. post merid.].

My calculation gives there the hour 7^h 50^m [7. 50/], so Tycho is later by a full 13 minutes [13/. minutis]. But since the eclipse was total, if (as I said in the preface) a soot [fuligo] had formed on the Moon, as often happens, and the penumbra drew out a spurious end, it will be no wonder that he judged the end to be so much later; from which it must follow that the middle, too, was

reckoned so much later. If we admit this, the agreement of the calculation with the observations will be close enough. The *exeligmos* [Exeligmus] of the year 1591 will smooth the way for us.

SECOND TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS IVNÆ TYCHONICA II.]

In the year 1576, on October 7, Tycho fixes the observed middle of the eclipse at Hven at 11^h 32^m after noon [Hor. 11. 32/ post meridiem].

My calculation gives this middle there at 11^h 37^m [hora 11. 37/]; so I depart from him by only five minutes, which is a slight difference. And perhaps I would not have disagreed by even that little, if the sky had been kinder to Tycho: for he adds that the magnitude [quantitatem] did not show, the sky being cloudy.

THIRD TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS IVNÆ TYCHONICA III.]

In the year 1577, on April 2, the Moon was totally eclipsed. Tycho fixes the middle of the eclipse at Hven at 8^h 50^m after noon [8. 50/. post meridiem].

My calculation arrives there at about 9^h 15^m [9. 15. ferme]. That is an enormous difference of 25 minutes, in which either I am wrong or Tycho is. If, as I believe, the penumbra here too drew out the end, it will be no wonder that Tycho was deceived [Tychoni factum fucum]. In any case, in Denmark Tycho saw only the end of this eclipse, and so made a conjecture about the middle. The *exeligmos* of the year 1595 will expose the error.

FOURTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS IVNÆ TYCHONICA IV.]

In the same year 1577, in the month of September, on the night between the 26th and the 27th, the Moon was totally eclipsed. At Hven the middle is stated to have been at 1^h 3^m after midnight [hor. 1. 3/. post mediam noctem].

My calculation shows this middle there at 1^h 17^m [hor. 1. 17'], so the difference is 14 minutes. This one, too, the *exeligmos* of the year 1595 will convict. Nor is it hard to guess what again clouded Tycho's eyes here: the end, namely, was true, but a spurious calculation pulled back the time of the middle as well.

For the rest, if ever on any other occasion, certainly here diligence was applied to obtaining an accurate observation of this eclipse, together with the work of men of note throughout all Spain. The aim was that by its help a map [Tabula] of Spain itself should be drawn up, and that the celebrated question between the Portuguese and the Castilians should be settled — concerning the meridian that divides the western lands and assigns the Molucca Islands to one side or the other. Lupus Velascus¹³ was chosen, so that the observations of all the others, sent here and there, should be compared against his. He, then, at Madrid [Madriti] fixed the last moment of the departing eclipse at 2^h 16^m after midnight [hora 2. 16' post mediam noctem].

¹³identification supplied — probably Juan López de Velasco, royal cosmographer of the Indies

Ioannes Alcantara [Juan Alcántara] observed the end at Toledo [Toleti] at $2^h 12^m$ [horâ 2. 12/.], as if the meridian of Madrid [Madritenfis meridianus] were a full 4 minutes east of Toledo's, whereas the two differ by only two minutes — an error scarcely perceptible.

Doctor Sobrinus [Sobrinus Doctor], at Valladolid [Valle-Olitânâ], caught the end at $2^h 8^m$ [hor. 2. 8'.]; so Valladolid would be 4 minutes west of Toledo.

Rodericus Zamoranus [Rodrigo Zamorano] determined the same end at Seville [Hifpali] at $2^h 4^m$ [horâ 2.4/]; so Seville will be 8 minutes west of Toledo.

In the Mexican world, at San Juan de Ulúa [Sanctum Ioannem de Luâ], the end was observed at $7^h 50^m$ after noon [7.50/]. From this it follows that that place lies $6^h 22^m$ [6. 22/.], or $95^\circ 30'$ [gradus 95. 30'.], west of Toledo.

At Puebla [Angelopolim], in the same Mexican region, the same end was obtained at $7^h 36^m$ [7.36']. Thus the interval between this place and the San Juan de Ulúa just mentioned [Luenfem] is 14 minutes, or $3^\circ 30'$ [3. 30'] of degrees to the west; and Puebla lies $6^h 36^m$ [6. 36] west of Toledo — that is, 99° [99.], determined accurately enough.

Since Mexico City itself lies one degree farther west than Puebla, Andreas Garcia Cespedius [Andrés García de Céspedes] rightly declares the interval between Mexico and Toledo to be exactly 100° [grad. 100. præcifè].

My calculation gives the end at Toledo most exactly, at the very moment $2^h 16^m$ [horæ 2. 16'], and at Madrid most precisely at $2^h 18^m$ [2. 18'] — so that I am myself quite astonished at so close an agreement.

FIFTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA V.]

In the year 1578, on the night between September 15 and 16, the Moon was eclipsed by about two and a half digits [digitis duobus cum semiffie circiter]. At Hven the middle was fixed at $1^h 17^m$ after midnight [post mediam noctem 1. 17'].

My calculation shows this middle there at $1^h 14^m$ [horâ 1. 14/.], so the agreement between us is excellent. I believe this was one of Tycho's fundamental eclipses, on which he built his restoration of the motions.

At Toledo the end was noted by Lupus Velascus at $1^h 20^m$ [hora 1.20']; at Puebla it was declared at $6^h 46^m$ after noon [horâ 6,46' post meridiem]. Here again, see, the difference between Toledo and Puebla is 6 hours

34 minutes [34.]¹⁴ — the least bit otherwise than in the preceding year [minimo minus aliter ac superiore anno]. This confirms all the more that interval of 99 degrees [99. graduum], and proves that Mexico is distant from Toledo by exactly 100 degrees [100 gradus ipfiffimos].

My calculation gives the end at Toledo at $1^h 3^m$ after midnight [hor. 1. 3. post mediam noctem]. There is therefore a fair discrepancy, which might perhaps be attributed to the duration of the penumbra. In any case the agreement with

¹⁴the page prints only "34."; the unit is construed from the sentence begun on the previous page, "6 hours ...".

Tycho's observation of the middle is TRULY MOST ADMIRABLE [SANE QVAM ADMIRABILIS].

SECOND SOLAR ECLIPSE [ECLIPSIS 2. SOLIS]

In the year 1579, of 5 digits 50' [Anno 1579 digitorum 5. 50'.]

Tycho records it on February 25, at 5^h 50^m after noon at Hven [die 25 Februarij horis 5. 50/ post Meridiem Huennæ]. Its exeligmos will be represented by the year 54 years later [annus abinde 54] — which was our 1633. We shall give both eclipses in the *Apotelesma* of the Atlantic Tables [in Apotelesmate Tabularum Atlanticarum].

SIXTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA VI.]

The first of my lifetime [Mei æui prima.]

In the year 1580, on January 31, there was a total eclipse, whose middle is fixed at Hven at 10^h 10^m after noon [horâ 10. 10' post meridiem].

Tycho noted this total eclipse; and Mästlin, in his *Isagoge* [in Ifagoge], states that *its latitude was a little less than the sum of the semidiameters, and that it therefore lay entirely in the shadow for a very short time*. Kepler too [Kepplerus quoq;], still a boy, with his father pointing it out to him, saw it whole and red all over. Let Lansbergen [Lansbergius] see to it, then, why he writes as follows: *The Moon was eclipsed almost totally, so that the small part of light remaining could scarcely be distinguished from the darkened part* — as if to say that the angle of contact had been made, or even that something of the Moon's body had remained outside the shadow. His calculation, to be sure, gives a partial eclipse, not a total one — contrary to what Mästlin saw.

My calculation has the Moon wholly immersed, but for a very short time, scarcely 3 or 4 minutes of time hidden [vix 3 aut 4 minutis horarijs abditam]. It reckons the middle at Hven at 10^h 30^m [horâ 10. 30'] — a full 20 minutes' discrepancy from the stated time, or rather from Tycho's calculation, which here too followed the penumbra long after the end had already passed [dudum à tranfacto fine]. But whatever there is of this, the exeligmos of the year 1598 will correct it.

I call this eclipse the first of my lifetime because, 127 days after it [medijs 127 diebus], I was born, on June 6 following.

SEVENTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA VII.]

The second of my lifetime [Mei æui secunda.]

In the year 1581, on January 19, Tycho fixed the middle of the total eclipse at the hour 9^h 57^m at Hven [in horam Huennæ 9. 57/]; Longomontanus [Longimontanus] gave 10^h 0^m [10, 0/] — a slight disagreement between master and pupil.

My calculation reckons the middle at Hven at 10^h 6^m [ad hor. 10.6'], with a closeness of a mere 6 minutes that cannot be vouched for [impræstabili

propinquitate exiguorum 6 minutorum]. I would not excuse even these, had Tycho left us anything more than his bare assertion.

EIGHTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA VIII.]

The third of my lifetime [Mei æui tertia.]

In the year 1581, on the night between July 15 and 16, the whole Moon was eclipsed again, at the hour 16^h 57^m after noon at Hven [horâ Huennæ post meridiem 16, 57'] — that is, 4^h 57^m after midnight [post mediam noctem 4. 57/]. But Tycho imposes this middle on us not from any observation at all but from his own conjecture and calculation. For he could see only its beginning; the immersion, the emersion and the end he could not, since all of these happened after moonset. So elsewhere he writes as follows: *This eclipse was at least observed to the extent that the Moon had entered the shadow by half before it set.* We therefore take nothing certain from Tycho's assertions.

My calculation obtains for Hven the beginning at 3^h 6^m [horâ 3.6'] and the middle at 4^h 45^m [hor. 4 45/], and so supports Tycho's observation equally well.

NINTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA IX.] [recte: TYCHONICA, per the book's errata]

The fourth of my lifetime [Mei æui quarta.]

In the year 1584, on the night between November 7 and 8, the Moon was totally eclipsed. Tycho set out the history of this eclipse in his *Epistolæ* [in Epistolis suis]. He states that he found the beginning at Hven at 11^h 12^m [hora Huennæ 11. 12'], and he has the end occurring at 15^h 0^m [horâ 15. 0']. So for him the duration is 3^h 48^m [horarum 3. 48'], and the middle falls at 13^h 6^m [13. 6']. And yet in the Catalogue [in Catalogo] he does not hesitate to give 13^h 12^m [13. 12']. From this he makes it plain that he is no longer reporting his observations faithfully, but presenting the calculation of his own tables. That is surely unworthy of such a man, and shows too much unconcern for criticism [nimia securitas cenfuræ]. We therefore rightly regard all his credibility, in other cases as well, as doubtful [fubleftam].

At Rostock [Roſtochij], Henricus Brucaeus [Heinrich Brucaeus], professor of mathematics there, determined this middle at 13^h 4^m [horâ 13. 4']. If that is true, the time at Hven cannot have been much other than 13^h 3^m [13. 3'], and Tycho indulged himself too generously when he wrote 13^h 12^m [13. 12].

At Kassel in Hesse [Caſſellis Haſſiæ], Wittichius [Paul Wittich], using the clocks or automata of his Prince [Horologijs feu Automatis fui Principis], determined on them the beginning at 11^h 20^m [hora 11. 20], the immersion at 12^h 20^m [12. 20], the emersion at 13^h 45^m [13 45], and the restoration of full light [Repletionem] at 14^h 45^m [14. 45], so that the middle was at 13^h 3^m [horâ 13. 3'], the whole duration 3^h 25^m [3. 25'] and the whole stay in the shadow [Mora tota] 1^h 25^m [1. 25']. Both clocks had been corrected by the azimuth [Azunuta] of the right shoulder of Orion. But Rothmannus [Christoph Rothmann] testified that due precision had not been applied.

And certainly the *exeligmoi* [*Exeligmi*] of this eclipse, which I saw and carefully observed in the years 1620 and 1638, will prove that its duration was neither the 3^h 25^m [horarum 3. 25] of Wittich nor the 3^h 48^m [3. 48] of Tycho, but quite plainly 3^h 36^m [3. 36] at most. My calculations give:

Place	Beginning [Initium]	Immersion [Immerfio]	Middle [Medium]	Emersion [Emerfio.]	End [Finis.]
	h.	h.	h.	h.	h.
Kassel [Caffellis-]	10 ^h 57 ^m	11 ^h 57 ^m	12 ^h 45 ^m	13 ^h 33 ^m	14 ^h 32 ^m
Rostock [Roſtochij-]	11 ^h 2 ^m	12 ^h 1 ^m	12 ^h 49 ^m	13 ^h 37 ^m	14 ^h 36 ^m
Hven [Huennæ-]	11 ^h 3 ^m	12 ^h 2 ^m	12 ^h 50 ^m	13 ^h 38 ^m	14 ^h 37 ^m

As far as I can see in the Hessian observation [in obſervatione Haſſiacâ], what drove Wittich [Wittichium] to correct the Prince's clocks [ad Horologia Principis corrigenda] was this: in part, the equation of days [dierum æquatio] was applied; in part, the culminations were slightly doubtful [Culminationes tantillò dubiæ]; and in part, a false appearance of the penumbra [penumbræ fucus] was drawn out past the end. So at the beginning it runs late [poſtumat] by 22 minutes, and toward the end by 12.

THIRD SOLAR ECLIPSE [ECLIPSIS SOLIS 3.]¹⁵

In the year 1584, of 3 digits 0' [Anno 1584 digitorum 3. 0']

Tycho writes that it occurred on April 30, Old Style [die 30 Aprilis veteris], at 5^h 39^m [horis 5. 39'] — he meant after midnight. My Atlantic calculation gives the morning hour 5^h 36^m at Hven [horam matutinam Huennę 5. 36], the moment at which the Moon was in the same longitude of the zodiac as the Sun. This is AN ADMIRABLE AGREEMENT [CONCORDIA ADMIRABILIS] with that observation — but one to be explained elsewhere with fuller apparatus.

TENTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA X.]

The fifth of my lifetime [Mei æui quinta.]

In the year 1587, on September 6, the middle of the eclipse is recorded at Hven at 9^h 16^m after noon [horâ poſt meridiem 9. 16']. Tycho, moreover, writes in his *Epistolæ* [in Epistolis] that he is sure enough of the middle of this eclipse to within 2 or 3 minutes. Let it be taken as certain, then, that this too is one of the fundamental eclipses on whose calculation he built his Tables.

My tables give the middle at Hven at 9^h 16^m [9. 16/] — AN AGREEMENT TO BE MARVELLED AT [CONSENSIONE ADMIRANDA].

ELEVENTH TYCHONIC ECLIPSE OF THE MOON [ECLIPSIS LVNÆ TYCHONICA XI.]

The sixth of my lifetime [Mei æui ſexta.]

¹⁵the book's errata (p. 130) directs that this solar eclipse "should have been placed before the preceding lunar one" (the ninth Tychonic lunar eclipse, of 1584 November, p. 48); the printed order is kept.

In the year 1588, on the night between March 2 and 3, Tycho notes the middle time of the eclipse at 15^h 2^m after noon [horâ post meridiem 15. 2'] — that is, 3^h 2^m after midnight [3. 2']. He writes of it as follows in his *Epistolae*: *The clear sky was moderate, and the middle was found to have exceeded the Prutenic calculation [calculus Prutenicus] by half an hour.* That calculation would give about 2^h 18^m [horam 2. 18' circiter], so this middle comes to just about 2^h 48^m [in horam 2. 48' admodum].

My calculation gives very nearly 2^h 44^m at Hven [horam 2.44' ferme Huennæ], and so comes fairly close to Tycho, on his own statement [vt is loquitur]. For the hours he sets down in the Catalogue [in catalogo], 3^h 2^m [3. 2.], he himself overturns elsewhere. Kepler [Kepplerus] is witness that it was written in the Tychonic volumes of observations [in voluminibus obseruationum Tychonicis] that the Moon lay altogether hidden and extinguished, and could only with difficulty be found when sought; and that at 2^h 58^m [ad horam 2. 58'] these words were added: *Now the Moon appeared brighter toward the east. Therefore the middle had passed* — and yet from the phases [Ex Phasibus] he conjectured it at 3^h 2^m [in 3. 2/].

Those phases indicate nothing other than a penumbra drawn out too long, when the true end had already long since been reached — something I have both pointed out and observed more than once.

At Herk [Hercæ], when my father was captain of the watch [præfecto Vigilum] and in charge of the clock [horologiū dispensante], the eclipse began around the middle of the first hour. The Moon was immersed after the middle of the second, emerged just after the third had been struck [post tertiam signatam], and ended a little after the fourth. The darkness was so great, although the sky was starry and clear, that when the watch had to be changed at the third hour no one could see where to set his foot. The middle was estimated at a quarter past the second hour [post quadrantem à secundâ]. All of this I remember hearing told, and not merely reading in writing.

My calculation gives at Herk: beginning at 0^h 33^m [Initium hor. 0. 33'], immersion at 1^h 34^m [Immerfionem 1. 34/], middle at 2^h 19^m [Medium 2. 19/], emersion at 3^h 2^m [Emerfionem 3. 2/], and finally the end at 4^h 4^m [Finem denique 4. 4'] — A SPLENDID AGREEMENT [CONSENSV PRÆCLARO].

At Lisbon [Vlyfippone], Doctor Sobrinus [?] observed the beginning of this eclipse at 11^h 56^m [horâ 11. 56'] — unless he rather meant to write 11^h 36^m [11-36/]; for then the agreement with the beginning at Herk [cum Initio Hercano] would be astonishing.

A Florentine nobleman [Florentinus Nobilis] noted the same beginning at Cape Correntes [ad promontorium Currentium], beyond the Cape of Good Hope [vltra Bonæ spei], at 4^h 15^m [hora 4-15/].

ECLIPSE OF THE MOON, the seventh of my lifetime [ECLIPSIS LVNÆ, Mei æui Septima.]

In the year 1588, in the Julian month of August, between the 26th and 27th [menfis Auguſti Gregoriani die inter 26 & 27] [recte: Auguſti Iuliani, per the book's errata], the most learned Sobrinus observed at Lisbon that the Moon began to be eclipsed at 1^h 49^m after midnight [horâ 1. 49' poſt mediam noctem]. The same eclipse was reported in writing to the King from Puerto Viejo in Peru, under the equator [ad Portum veterem Peruuiæ ſub æquatore], at 8^h 54^m [horâ 8. 54']. So the difference of meridians is 4^h 55^m [hor. 4. 55'], which makes 73° 45' of longitude [gradus Longitudinis 73. 45'].

My calculation gives the beginning at Lisbon at 2^h 0^m after midnight [hora 2. 0' poſt mediam noctem]. The discrepancy of 10 minutes would perhaps be none at all, if we knew by what method Sobrinus determined the time.

ECLIPSE OF THE MOON, the eighth of my lifetime [ECLIPSIS LVNÆ, Mei æui Octaua.]

In the year 1589, in the Gregorian month of August, on the 25th, in the evening, my father and others noted the end of the eclipse at Herk [Hercę] at about a quarter before eight [quadrante circiter ante octauam].

My calculation gives exactly 7^h 47^m [horam 7. 47/ omnino], and agrees excellently with the observation.

ECLIPSE OF THE MOON, the ninth of my lifetime [ECLIPSIS LVNÆ, Mei æui Nona.]

In the year 1590, on July 17, in the morning, Mästlin [Meſtlinus] at Tübingen [Tubingæ] observed the Moon deficient by some digits on the south side [ab Aufro]. When the Sun's centre was emerging above the horizon, the Moon herself was still almost 2 degrees high. Conversely, as the centre of the Moon was sinking below the horizon, the Sun appeared already raised by about 2 degrees [quafi grad. duobus]. Some think this should be referred to extraordinary refractions [ad Refractiones extraordinarias]. But there is no need at all for this extraordinary remedy. For the Moon was strongly northern, by about one degree [quafi ad gradum vnum], which the parallax depressed. So the refractions — of the Moon on one side and of the Sun on the other — added up, if not to 2 degrees, then at least to more than one. Mästlin added that the Moon had set before it had reached its greatest obscuration. On that day the Sun rises at Tübingen [Tubingæ] at 4^h 15^m [hora 4.15/]; but since it had already been raised about two degrees above the horizon, it may easily have been 4^h 20^m [horâ 4.20/], no less. So the greatest obscuration came after that time.

My calculation gives the beginning at Tübingen at 3^h 38^m [horâ Tubingæ 3.38/], and the middle at 4^h 28^m [horâ 4.28/]. Thus the greatest obscuration truly answers to the observation AND TO THE CALCULATION, MARVELLOUSLY [ET CALCULO AD MIRACVLVM].

ECLIPSE OF THE SUN 4 [ECLIPSIS SOLIS 4.] In the year 1590, of 5 digits 0' [Anno 1590 digitorum 5. 0/]

Tycho records its middle on July 21, Old Style [die 21 Iulij veteris], at 7^h 54^m [horis 7.54/]. Understand this, again, as counted after midnight: for it happened in the morning, as I remember hearing from my father when I was a boy.

ECLIPSE OF THE MOON, TYCHONIC XII, the tenth of my lifetime [ECLIPSIS LVNÆ TYCHONICA XII. Mei æui decima.]

In the year 1590, Old Style [Stili veteris], on December 30 — that is, in the year 1591 on January 9, Gregorian — Tycho noted the middle of the partial eclipse [medium deliquij partialis] at Hven [Huennæ] at 6^h 55^m [6.55/] after noon.

My calculation gives the hour there as 6^h 50^m [6.50/], a discrepancy of no more than 5 minutes, which is almost imperceptible.

ECLIPSE OF THE SUN 5 [ECLIPSIS SOLIS 5.]

Tycho records one in the year 1591, on July 10, at 3^h 33^m [hora 3 33/], of two and a half digits [digitorum duorum cum femiffe]. The time was in the afternoon. It is to be compared with our calculations elsewhere.

ECLIPSE OF THE MOON, the eleventh of my lifetime [ECLIPSIS LVNÆ, Mei æui vndecima.]

In the year 1591, on December 30, Gregorian, in the morning, the Moon began to be eclipsed at Herk [Hercæ] — our night watchmen [excubitoribus nostris] observing it — at a quarter past two. It was immersed at a quarter past three. It emerged, with very many people now watching, a little before five. It was refilled [Repleta est] a half-quarter before six. On this basis the middle would have been at 4^h 4^m [horâ 4. 4/] or a little later.

My calculation gives the beginning at 2^h 18^m [hor. 2.18/], the immersion at 3^h 16^m [3.16/], the emergence at 4^h 55^m [4.55/], and the refilling at 5^h 53^m [5.53/]; from which the middle comes out at 4^h 6^m [horâ 4.6].

I remember that as a boy, hurrying to morning school, I arrived when it was already over. After stopping for a while to listen to people describing it, I finally went into the school as six was striking — so that about that half-quarter I am sufficiently certain even on my own account.

This eclipse is the exeligmus [Exeligmus] of the year 1573. So if Tycho wavered there by some minutes, those figures are warned of their error and corrected by this eclipse: for if there was as much lateness there as Tycho shows [traditas] [recte: tarditas], the same ought to have been felt here too.

And indeed my Atlantic calculation agrees with this observation VERY ACCURATELY [PERQVAM ACCVRATE], wavering by scarcely two or at most three minutes. But since this is domestic testimony, let us wait to see what the exeligmus of 36 years [Exeligmus annorum 36], together with the beginning of the year 1628 [vna cum anno 1628 ineunte], will yield. For that eclipse was observed accurately in various places and by practitioners skilled in these matters, Kepler [Kepplero] above all.

ECLIPSE OF THE MOON, TYCHONIC XIII, the twelfth of my lifetime [ECLIPSIS LVNÆ, TYCHONICA XIII Mei æui duodecima.]

In the year 1592, on June 14, Julian — that is, June 24, Gregorian — Tycho marks the middle of the eclipse at $10^h 16^m$ [horâ 10. 16/] after noon at Hven, with a defect of 8 digits. Let us weigh what sort of things these are. Sunset at Hven fell at $8^h 40^m$ [horam 8. 40/]. So if the middle of the eclipse was at $10^h 16^m$ [horâ 10. 16/], the beginning must certainly have fallen at least at $8^h 42^m$ [fâtem in horam 8. 42/], at which time the Moon had not yet risen above the horizon; for its latitude was rather southern, so that even with the help of refractions it could not have risen before $8^h 50^m$ [hor. 8. 50/].

But after it had risen, and before the eclipse, Tycho "*observed its diameter, still whole, with the radius*" [diаметrum eius adhuc integræ obseruauit radio], and found it to be 32'. So there was some little time between the rising of the Moon and the beginning of the eclipse. Let this be noted, then — and this too: that around the middle of the eclipse he found 14' [14/] of those 32' of diameter remaining, so that 18' [fcrupula deficientia 18/] were deficient, that is, not quite 7 digits. "*But this magnitude departs a long way from his own calculation, which claims 26' of the Moon's body for the shadow*" [qui 26 minuta corporis Lunarîs Vmbræ vendicat] — that is, nearly 10 digits. Between these figures, so discordant, he strikes a middle and enters 8 digits in his catalogue. So, while accommodating himself both to his calculation and to the observation, he thrusts on us what he can — or rather, what he wants.

Kepler [Kepplerus], excusing these things, says: "*This I attribute to the difficulty of observing. For even if someone should call into doubt the Tychonic calculation, or the diameter of the shadow (on which elsewhere), he will never bring it about that this eclipse, with this magnitude, squares with the others.*" So he writes in the *Optics* [Optices], page 350.

Nothing here, then, is sound — at least nothing of the kind that it would be fitting to vouch for under Tycho's name. One thing we take away: that both the beginning of the eclipse [Initium deliquij] and its middle occurred later than Tycho reported.

My calculation gives the beginning at Hven at $8^h 57^m$ [horâ 8.57/], about a half-quarter after the full rising of the Moon, and puts the middle at $10^h 31^m$ [hor. 10.31/], with a little more than 9 digits. MOST CORRECTLY [RECTISSIME].

ECLIPSE OF THE MOON, TYCHONIC XIV, the thirteenth of my lifetime [ECLIPSIS LVNÆ TYCHONICA XIV. Mei æui decima-tertia.]

In the year 1592, on December 8, Old Style [antiqui] — the 18th, New Style [18 Nouij] — Tycho fixes the middle of the lunar eclipse at Hven at $7^h 41^m$ [horâ 7.41/].

At Goes [Gouzæ], Lansbergen [Lansbergius] writes that he found the middle at $6^h 50^m$ [horâ 6. 50/] and the end at $8^h 0^m$ [horâ 8. 0/]. This does not agree with Tycho's middle; for on that basis the middle at Hven would have been at $7^h 22^m$ [hora 7.22/] only, and no later.

My calculation gives the middle at Goes at 6^h 49^m [h. 6.49/], and at Hven at 7^h 21^m [h. 7.21.] — AN ADMIRABLE AGREEMENT [CONSENSV ADMIRABILI].

ECLIPSE OF THE MOON, TYCHONIC XV, the fourteenth of my lifetime [ECLIPSIS LVNÆ TYCHONICA XV. Æui mei decima-quarta.]

In the year 1594, on October 19, Julian — that is, October 29, Gregorian — the middle of the eclipse is recorded at Hven at 7^h 26^m after midnight [horâ post mediam noctem 7. 26']. That middle rests on pure conjecture, for only the beginning of the eclipse [initium deliquij] could be seen; and Kepler [Kepplerus] (*Optics*, p. 413 [Opt. p. 413]) reports it observed at 5^h 56^m [horâ 5. 56/].

At Goes [Gouzæ], Lansbergen [Lansbergius] writes that he observed the beginning at 5^h 12^m [horâ 5. 12/], whereas he ought to have found it at 5^h 24^m [h. 5. 24/], if Tycho is right.

My calculation gives the beginning at Hven at 5^h 56^m [horâ 5. 56/] and the middle at 7^h 28^m [horâ 7.28/] — AN ASTONISHING AGREEMENT [c o s e n s i o s t v p e n d a], which by itself alone commends all my hypotheses.¹⁶

ECLIPSE OF THE MOON, TYCHONIC XVI, the fifteenth of my lifetime [ECLIPSIS LVNÆ TYCHONICA XVI. Æui mei decima-quinta.]¹⁷

In the year 1595, between April 13 and 14, Julian — that is, on the morning of April 24, Gregorian — Tycho determined the middle of the eclipse at Hven at 4^h 36^m [horâ 4. 36'] after midnight. Origanus reckons that this same middle fell at Frankfurt an der Oder [Francofurti ad Oderam] at 4^h 50^m [hor. 4. 50/], since that place lies further east and is separated from Hven by 12^m [minutis 12]. Let us see from other sources what the observations gave.

At Goes, Lansbergen writes that he had the beginning at 1^h 40^m [horâ 1. 40/], the immersion at 2^h 40^m [Immerfionem 2. 40/] and the emersion at 4^h 20^m [Emerfionem 4. 20']. The end, he writes, could not be seen, because the Moon went down below the horizon. The struggle [Lucta], then, lasted a whole hour; the stay [Mora] was 1^h 40^m [1. 40']. The middle is inferred at exactly 3^h 30^m [horâ 3. 30' præcifê].

Here with us at Herk [Hercæ], while the things I needed for setting out to my studies at Tournai [Tornacum] were being got ready, our household [nostri] observed the beginning of the eclipse [Principium deliquij] when the second hour had barely struck. The Moon was immersed just at the third hour itself [sub ipsiffimam tertiam]. It emerged at about 4^h 38^m [horâ 4. 38/], roughly a quarter of an hour before it set, having by then recovered much of its light.

¹⁶the letter-spaced small capitals read *COSENSIO*: no *n* stands between the *o* and the *s* on the scan, and no suspension mark over the *o* is visible.

¹⁷the heading sets *TYCHONICA*, the letter after *H* showing as an open *C*, and spaces *ECLIPSIS*.

That, then, is how things went here with us, where the Sun rose at $4^h 56^m$ [hor. 4.56']. So, by a rough estimate, the middle will have been at about $3^h 48^m$ [ad horam 3.48']. Since this is true enough, Lansbergen's middle at Goes ought to have been caught at $3^h 40^m$ [horâ 3.40/], not, as he has it there, at $3^h 30^m$ [3.30/]. So, just as in the eclipse of the previous year he anticipated the time by a full 10 minutes of time [ad 10. tota minuta horaria], here too he ran ahead by as many.

Meanwhile this much is already clear: these phases could not, at least, be put any later, if both Lansbergen and our people saw the emersion and a large part of the light recovered. It follows that at Hven the beginning must have been seen at $2^h 25^m$ [horâ 2.25'], no more. Kepler writes that it was inferred there at $2^h 51^m$ [horâ 2.51'] — an enormous error of 26 minutes of lateness. Origanus, at least, would have reckoned $2^h 41^m$ [2.41']. Nor could the middle at Hven have gone beyond $4^h 13^m$ [horam 4.13'], or 15^m at the most [vel fommùm 15/] — much less have reached the 36th minute [minutũ 36].¹⁸

At Graz in Styria [Gratij Stiria], Kepler writes that when the beginning was noticed, he took, rather roughly [pinguiusculè], with a small quadrant, the altitude of Arcturus [Arctari] [recte: Arcturi, per the book's errata] as 44° [partium 44] and that of the Moon as $15^\circ 30'$ [15. 30']; from these he derives the hour $4^h 59^m$ [horam elicit 4. 59']. By our observations this could not have exceeded $4^h 45^m$ [4. 45/] — a discrepancy of at least 14 minutes [falterm 14'. minutorum], which is somewhat more tolerable than Tycho's.

By a most happy chance, however, it turned out that between Lansbergen's acceleration and Kepler's retardation the observation at Herk [Hercana obseruatio] went exactly down the middle way; and even in this way it secured credit for itself as a lawful time, determined accurately enough. My father, certainly, a distinguished mechanician [Mechanicus] in other respects, was also quite knowledgeable in these matters. So, to set my calculation of this eclipse before your eyes: from my Atlantic Tables [Tabulis meis Atlanticis] the following resulted:

Phase	Goes [Gouzæ.]	Herk [Hercæ.]	Hven [Huennæ.]	Graz [Gratij.]
Beginning [Initium.]	$1^h 54^m$	$2^h 1^m$	$2^h 26^m$	$2^h 45^m$
Immersion [Immerfio.]	$2^h 50^m$	$2^h 57^m$	$3^h 22^m$	$3^h 41^m$
Middle [Medium.]	$3^h 41^m$	$3^h 48^m$	$4^h 13^m$	$4^h 32^m$
Emersion [Emerfio.]	$4^h 30^m$	$4^h 37^m$	$5^h 2^m$	$5^h 21^m$
End [Finis.]	$5^h 28^m$	$5^h 35^m$	$6^h 0^m$	$6^h 19^m$

Nor do I think there will ever be anyone hereafter who will not admit that these times, as I have computed them, are perfectly true and entirely lawful, so that no occasion for doubt will remain.

ECLIPSE OF THE SUN 6 [ECLIPSIS SOLIS 6.]

¹⁸the page sets *fommùm*, read here as *summùm*, "at the most".

Tycho records it in the year 1595, on September 23, at 1^h 8^m [horâ 1. 8'] (understand: after noon), of 3 digits 50' [digitorum 3. 50'] — to be examined elsewhere.

TYCHONIC ECLIPSE XVII, the sixteenth of my lifetime [ECLIPSIS TYCHONICA XVII. Mei æui decima-Sexta.]

In the same year 1595, on October 18, Gregorian, in the morning, Tycho records the middle of the eclipse at Hven at 8^h 36^m [horâ 8.36'] after midnight. But since he could have seen nothing except the beginning, and that not for very long (the Sun rising there at 6^h 57^m [horâ 6.57']), here too Tycho's practice — refuted so many times already — plainly shows itself: inventing middles for himself and thrusting them on us. Would that he had been content to show us the simple truth! Accordingly, his companion Longomontanus [Longimontanus], in his catalogue, gives only 8^h 30^m [horam 8. 30. tantum] — and that, likewise, from nothing but conjecture.

My calculation computes the beginning at Hven at 6^h 48^m [horâ 6.48'], the immersion at 7^h 53^m [7.53], and the middle at 8^h 44^m [8.44]. And this truth will be brilliantly confirmed by the most accurate exeligmos of the year 1631 [Exeligmus anni 1631 accuratissimus].

TYCHONIC ECLIPSE XVIII, the seventeenth of my lifetime [ECLIPSIS TYCHONICA XVIII. Æui mei decima-Septima.]

In the year 1596, on April 12, Gregorian, Tycho marks the middle of the eclipse at Hven at 9^h 29^m [horâ 9.29'] after noon; Longomontanus, at least, puts forward 9^h 25^m [9.25]. The magnitude of the greatest defect could not be seen.

When the most learned Pétau [Petavius] examined this eclipse against his own Tables and saw how enormously it departed from them, he also consulted various calculations by other authors; yet he found none of them agreeing with Tycho's stated value. No wonder. For Tycho himself writes his own refutation [Elenchum] when he adds that the middle and the greatest defect were not visible. I seem to see it plainly: only the beginning was observed at Hven; the rest was not visible because of clouds; and so a middle fabricated out of pure conjecture, or carved out of the Tables, is being thrust upon us.

In fact, at Tournai, many of our masters, young students and other citizens were watching. Evening had barely begun — the various town clocks had just struck seven, and the Moon had risen only a little above the horizon and certain houses — when the eclipse began, and it lasted until exactly 9^h 15^m [9. 15.]. Thus the whole duration did not exceed 2^h 12^m [2. 12'.], and the middle there fell at 8^h 10^m [8.10.], precisely enough. Since this is true, it follows that the middle at Hven should be assigned to 8^h 45^m [8. 45'.] only, hardly more. Tycho therefore lags by a full 44 minutes, and Longomontanus [Longimontanus] by at least 40 — an enormous interval, and one not to be excused on any pretext [villo colere] [recte: colore, per the book's errata]. The exeligmos of the year 1614 [Exeligmus anni 1614.] will plainly refute it as well.

My Atlantic calculation gives, for Tournai, the beginning at 7^h 4^m [Init. hor. 7.4'.], the middle [Medum] at 8^h 10^m [8.10.], and the end at 9^h 16^m [9.16'.] — an excellent, not to say ADMIRABLE AGREEMENT [ADMIRABILIS CONSENSVS] with what was observed. For Hven it reckons the beginning at 7^h 40^m [Init. 7. 40'.], the middle at 8^h 46^m [Med. 8. 46.], and the end at 9^h 52^m [Fin. 9. 52.] — and I know Pétau will be glad of these when he reviews them.

TYCHONIC LUNAR ECLIPSE XIX, the eighteenth of my lifetime
[ECLIPSIS LVNÆ TYCHONICA XIX. Æui mei decima-octaua.]

In the year 1598, on February 21, Gregorian, in the morning, there was an eclipse of the Moon, whose middle the Tychonic catalogue records at Hven at 6^h 7^m [6.7.] from midnight. Tycho was no longer there, since he had left Denmark in indignation the year before. But after reduction to the meridian of Hven, it was believed that the middle ought to be fixed in this way. Otherwise, Origanus at Frankfurt an der Oder determines it from the Tychonic Tables at 6^h 12^m [horâ 6'. 12'.], as though the hour at Hven were to be understood as 6^h 0^m [6. 0'.].

At Wittenberg [Wittebergæ], Melchior Ioftelius [Melchior Jöstel] described this eclipse and, on Tycho's advice, published a little book about it, which I have not yet had the chance to see.

At Graz [Gratij], Kepler [Kepplerus] described the same eclipse in these words (*Opt.*, p. 368 [Opt.pag. 368.]): "*At the time when the town bell was striking the third hour, Spica stood 56° 40' [grad. 56. 40'.] from the zenith, by a wooden quadrant of a span's radius [quadrante ligneo spithamali]. This altitude of Spica would add 24 minutes to the town hour. So at 4^h 30^m [4. 30'.] by the town clock*" (that is, 4^h 54^m [4.54.] celestial) "*I could not yet make out the defect; but because of clouds it could have begun then. For less than two quarters of an hour later the Moon, not yet darkened as far as half, stood fully upright. A little after five*" (by the town clock, that is, 5^h 24^m [5.24.] celestial) "*half the diameter was deficient, the Moon now tilted. A little before six*" (by the town clock, that is, in truth 6^h 20^m [6 20'.] celestial) "*she withdrew behind clouds with a very thin light, so that she seemed still to be waning and about to lose all her light. The beginning, then, would fall a little before five; the last phase about 20 minutes after six. And that was around the middle. For at Wandsbek [Wandesburgi]*" (where Tycho was then staying) "*she was observed not to be totally eclipsed. The Tychonians, moreover, put the middle of this eclipse*" (the observation of the beginning assisting the calculations, for the end was below the horizon) "*at 6^h 5^m [6. 5.] at Hven.*"

At Louvain [Louanij] it began a little after four in the morning, while we were being roused for our morning duties of prayers and studies; so that I would venture to say that the time of the beginning was 4^h 10^m [4. 10.], or not much otherwise — it was certainly not yet a quarter past four.

At Goes [Gouzæ], Lansbergen thinks he had the same beginning at 3^h 40^m [3. 40.], and the middle at 5^h 23^m [5.23.] — which I know to be utterly false, both from the beginning at Louvain and from that at Graz.

At Aachen [Aquisgrani], Ioannes Rotarius [?] (so far as Lansbergen testifies) observed the beginning at 4^h 30^m [4. 30'.]. He inferred the middle at 5^h

30^m [30'.]. Remarkable here is either the carelessness of the observers or the sham Lansbergen practises on us by thrusting the numbers of his own Tables upon us. I judge that Kepler is to be trusted; and with his beginning our own at Louvain likewise agrees admirably.

My Atlantic calculation gives, for Louvain, the beginning at 4^h 8^m [horâ 4. 8'.], the middle at 5^h 51^m [5. 51.], and the end at 7^h 33^m [7. 33.]. For Graz the same phases are set at 4^h 54^m [4. 54'.], then 6^h 37^m [6. 37.], and finally 8^h 19^m [8. 19] — which is an ADMIRABLE AGREEMENT [CONSENSIO ADMIRABILIS].

Origanus [Origamus] [recte: Origanus], besides erring in the times, binds himself to a great offence besides, when he makes the eclipse total, of 12 digits 32' [digitorum 12. 32'.], and holds that the Moon lay hidden in the shadow for about 37 minutes [minutis 37 fermè]. Yet neither Lansbergen, nor the observers at Wittenberg [Wittebergenfes], nor the Tychonians at Hven, nor finally Kepler himself detected a defect of more than 11 digits 30' [11. 30'] — nothing more.

My Tables represent those 11 digits 30' [11.30.] so accurately that not the slightest thing is lacking: A MARK OF PRIME EXCELLENCE [NOTA BONITATIS PRIMARIA].

ECLIPSE OF THE SUN 7 [ECLIPSIS SOLIS 7.]

In the same year 1598, on the seventh day of March, Gregorian, there was a memorable eclipse of the Sun. Lansbergen writes that he observed its greatest defect at Goes at 2^h 20^m before noon [horâ 2. 20'. ante meridiem], "*when the Sun was wholly eclipsed; and the darkness was so great that it seemed like twilight night; but the true magnitude of the defect could not be determined by us because of the cloudy sky.*" So he writes.

At Louvain, too, the sky was cloudy; and besides that very inconvenience, we in the lecture hall of logic [auditorio Logico] were obliged to take down our master's dictation. About a quarter of an hour before ten, however, such darkness came on that we had to stop writing for some time.

At Torgau in Meissen [Torgæ in Misniâ], Doctor Jessenius [Jeffenius] observed the Moon wholly contained within the circuit of the Sun, enclosed all round by a shining ring — a spectacle he also celebrated in a poem.

At Frankfurt an der Oder, Origanus *observed the beginning at 10^h* [obferuauit initium horâ 10.]

20^m [20'], he had two digits at 10^h 32^m [horâ 10. 32'.]. *It reached six digits at 10^h 56^m [10.56']. After that, 9 digits were noticed at 11^h 28^m [11.28']. And again 9 digits appeared at 11^h 46^m [11.46']. Next there were 6 digits at 12^h 16^m [12.16']; 3 digits at 12^h 25^m [12.25']. The end was finally observed at 12^h 32^m [hor. 12.32']. These things Origanus then drew from the sky. Afterwards, when he had obtained the Tychonic Tables and compared this observation of his with their calculation, he*

was greatly astonished that so exact a determination could have been applied to the motions of the Sun and Moon that the calculation departed from those observations by scarcely anything at all. So, more or less, Origanus.

At Wandsbek near Hamburg [Wandesburgi iuxta Hamburgum], Tycho observed the beginning with the armillary instruments [per Armillas] at $9^h 52^m$ [horâ 9. 52'], which would be $10^h 4^m$ at Hven [Huennæ horâ 10.4'] — as Kepler adds (*Optics*, p. 383 [Opt. pag.383.]).

At Hven itself, indeed, a certain student of Tycho's, who was on the island at the time for the sake of observing, reported the beginning at $10^h 3^m$ [horâ 10.3'], the end at $12^h 32^m$ [12.32'], the duration $2^h 29^m$ [Duratio horâ 2.29'], the middle at $11^h 17^m 30^s$ [11. 17'.30"], and 9 digits 40' [Digiti 9.40.] — on the testimony of the same Kepler.

At Graz [Gratij], Kepler lacked suitable instruments and the sky was cloudy; even so, from two indications he obtained the end at $12^h 55^m$ [horâ 12. 55'], and from calculation he judges that the beginning took place at $10^h 19^m$ [horâ 10. 19']. He thus fixes the middle at $11^h 37^m$ [Horâ 11. 37'], with 6 digits, about noon itself. When this middle is compared with the one at Hven, a difference of meridians of about 20 minutes, or five degrees, is gathered — "provided" (he says) "that everything employed was properly established."

For my part, in the Table of places I have already given Hven $2^h 18^m 30^s$ [horas 2.18'.30"] and Linz [Lincio] $2^h 33^m$ [2.33.]. To Graz, therefore, which is 4 minutes farther east, there belongs $2^h 37^m$ [2.37.]. So I present the difference as $18^m 30^s$ [minutorū 18'.30"] — which agrees excellently with this observation and with Kepler's conclusion, which I read on p. 359 [pag.359] in these very words: "The true conjunction at Hven is now sought. So at $10^h 59^m$ [horâ 10. 59'] is the moment of true conjunction; at Graz, at $11^h 17^m$ [horâ 11. 17']. The difference of meridians is 18' [18'], or of degrees 42.30' [graduum 42.30']¹⁹. And this was what had to be investigated on this occasion."

Now, since it is quite certain that Graz is farther east than Linz by four minutes of time [minutis horariis quatuor] — as many as Kepler himself, a resident of those places, declares in his Catalogue — it surely ought to be beyond doubt that between Hven and Linz there lie 14 minutes [minuta 14.], no fewer — exactly as many as my own Catalogue has expressed, whose reliability is confirmed from this as well.

I have included this eclipse among the lunar ones for these reasons: it was the first of them that it fell to me to perceive; the Sun was entirely covered elsewhere, in a central conjunction, which will in due course be of the greatest importance for the demonstration of the parallaxes [ad Parallaxium demonstrationem]; and finally, it throws further light on the distance between Graz and Hven, and so on that of other places as well. Now let us proceed to the remaining lunar eclipses.

¹⁹so printed; 18' of time corresponds to $4^\circ 30'$

ECLIPSIS LVNÆ TYCHONICA XX. — Tychonic Lunar Eclipse XX

The nineteenth of my lifetime [Æui mei decima-nona].

In the year 1598, on the 16th of August, Gregorian [Anno 1598. die 16. Augusti Gregoriani].

Tycho's Catalogue marks the middle of the eclipse at HVEN [HVENNÆ] at 7^h 37^m after noon [horâ 7. 37'. post meridiem], which Origanus, from the same man's calculation, would put at 7^h 32^m [in horam 7,32'.].

At GOES [GOVZAE], "the end" (says Lansbergen) "was accurately observed by us at 8^h 40^m after noon" [horâ à meridiem 8. 40'] — and let that moment stand as certain.

My Atlantic calculation gives the middle at Goes at 7^h 2^m [horâ 7.2'.], and the end at 8^h 40^m [8.40'] most precisely. At Hven, too, I find the middle at 7^h 34^m [horâ 7.34'.]. NOTHING COULD BE MORE ACCURATE [PLANE NIHIL ACCVRATIVS].

ECLIPSIS LVNÆ TYCHONICA XXI. — Tychonic Lunar Eclipse XXI

The twentieth of my lifetime [Æui mei vigesima].

In the year 1599, on the 31st of January Old Style, that is, on the 10th of February Gregorian [die 31. Ianuarij veteris, hoc est, die 10. Februarij Gregoriani], the middle time of the total eclipse was noted at Hven at 5^h 56^m after midnight [hora post mediam noctem 5. 56.], with Longomontanus [Longimontano] observing, since Tycho had by then left for Bohemia.

Kepler (*Optics*, p. 249 [Optic.pag.249.]) watched the same eclipse, but without instruments. Relying instead on the town clock [vrbs horisio], he judged the beginning of the defect to come when the clock was striking three quarters toward four; and when four struck, a good part was already eclipsed.

My calculation grants Hven the middle at the very hour and minute of the hour, 5^h 56^m [5. 56'], that the Catalogue shows. This is an ASTONISHING AGREEMENT [CONSENSIO STVPENDA].

ECLIPSE OF THE SUN 8 [ECLIPSIS SOLIS 8.]

Reported to Tycho for the year 1599 and the 12th of July, in the morning, at 16^h 8^m after the preceding noon [horis 16. 8'. post antecedentem meridiem] — that is, at 4^h 8^m after midnight [horis 4.8'. post mediam noctem] — it had 3.0 digits there [digitos illic habuit 3.0.]; these are to be set out more fully elsewhere.

And these are the Tychonic eclipses (enlarged by a very few additions). Of them, the autumnal one of 1578 [Autumnalis 1578.], the summer one of 1581, and also those of 1587, 1594 and 1598, together with 1599, answer to my calculations as accurately as Tycho himself could demand — he counts it a great thing *if one is sure to within two or three minutes*. Others, it is true, stray

somewhat more loosely; but they are excusable because of the deception of the penumbra [penumbræ fucum], and are easily brought to the true reckoning of time. Others, which depart the farthest, are either reserved for their exeligmoi [Exeligmis suis] — that is, for the recurring periods of 18, 36 or 54 years — or else are refuted, on the matter at hand, by other observers who come in later: Kepler, Lansbergen, Céspedes [Cespedio] — to say nothing of my own (childish ones, if you like, at that time).

Yet I would not have this taken as though I wished to detract anything from the glory of Tycho, to whom Astronomy owes almost the whole of itself. It is said so that we may understand that his eclipses did not stand entirely, as to their middle moments, in the way they were recorded — recorded not by Tycho himself, but by the man who presided over the fitting together of his hypotheses and over the whole calculation, Christianus Severinus Longomontanus [Christianus Seuerinus Longimontantus]. We can argue this the more confidently because, when he later issued the Danish Tables [Danicas Tabulas] in the year 1622, he recorded different times for many eclipses — being not scrupulous enough toward the sky.

So let Tycho close the century just past, and let new observations open the new one: not so renowned for costly instruments, perhaps, but no less certain for their simplicity. For it is certain that a road is the smoother, the fewer obstacles — or indeed none at all — roughen it [inscabratur]; and that is what I have always looked to first in making my observations.

These observations I give in good faith, just as I took them from the sky, partly in Gallia Narbonensis and partly in the Low Countries [Belgio], and, whenever I could, confirmed by the testimony of others observing elsewhere. For I am well aware how much ill will it draws — especially in this century of ours — to bring before the public something new and unheard of, or never said before, on which the construction of a new doctrine is to be raised. Indeed I long debated with myself whether I should not bury my observations entirely in silence, hateful as they were even to me, and bring forward as evidence only those that other practitioners had made, which I have always valued more highly than my own. Yet, so as not to condemn my own labours and night-watches of my own accord, and not to cheat the public of something that may perhaps please it, I shall give every one of them, as many as there are. And whenever they are to hand I shall add the testimonies of others too — if not all of them (for where would it end?), then at least those of the most outstanding practitioners [Artificium], to whom this art devotes itself.

Whatever has been said so far about this period that preceded the new century, I ask good men to take in good part — not so much for my own sake as for the sake of my friend IVSTVS DVDINGIVS CLIVIVS [?], who did not think these things should be passed over, and who even offered himself of his own accord as amanuensis for all my work, if times and places allow — both of which, I hope, GOD will grant.

**LUNAR ECLIPSES OBSERVED, CHIEFLY THROUGH-
OUT EUROPE, FROM THE OPENING OF THE NEW
CENTURY [ECLIPSES LVNARES, A NOVO INEVNTE
SÆCVLO per EVROPAM potissimùm obseruatæ.]**

FIRST ECLIPSE OF THE MOON [ECLIPSIS LVNÆ PRIMA,]

The twenty-first of my lifetime [Æui mei vigesima-prima,]

*Which occurred in the secular year 1600, on 30 January Gregorian, in the morning
[Quæ contigit Anno sæculari 1600. die 30. Ianuarij Gregoriani, manè.]*

At Calidianum [CALIDIANI], a town of the diocese of Fréjus [Diocesis Foro-Iuliensis] in Provence, lying 6 minutes of time east of Aix [Aquis-Sextiis], the Moon began to fail for us in the morning, with a quarter still remaining before the sixth (true) hour [quadrâte adhuc in horam sextum (veram) reliquo]; and 2 digits were eclipsed, toward the north. But the Moon soon set, as seven was striking, not yet restored entire, when the defect had already lasted more than an hour. A quarter of an hour later the Sun rose, at 7^h 10^m there, and this corrected our clock [horisonium] for us.

My Atlantic calculation [Calculus meus Atlanticus] gives this beginning at Calidianum at 5^h 46^m, agreeing most precisely with the observation, by the hypothesis of equal days [Dierum æqualium] and the oscillatory prostaphæreses [Prostaphæreses oscillatorias] — WHICH I HAVE UNDERTAKEN TO DEMONSTRATE [QVOD MIHI SVSCEPI DEMONSTRANDVM].

The Tychonic calculation would give the beginning there at 5^h 49^m, with almost no error; but it delays the middle by 15 minutes.

In the same secular year 1600 — THE NINTH OF THE TYCHONIC ONES [TYCHONICARVM NONA] — there occurred an ECLIPSE OF THE SUN on 10 July Gregorian. Kepler [Kepplerus] described it very fully in his *Paralipomena* [Paralipomenis suis], as observed by himself and by others at differing magnitudes. It will be weighed in its proper place, together with what I learned had been observed of it in Provence; for by then I had already left there and set out for Italy.

SECOND ECLIPSE OF THE MOON [ECLIPSIS LVNÆ SECVNDA.]

The twenty-second of my lifetime [Æui mei vigesima-secunda.]

In the year 1601, on 9 December, in the evening [Anno 1601. die 9. Decembris, vespere.]

Tycho, intending to give a specimen of his Tables, computed the middle of this eclipse [deliquij] for Hven [Huennæ] at 6^h 56^m, and its whole duration at 3^h 36^m, with about 11 ecliptic digits [digitis Eclipticis]. But it is certain that an error crept into the calculation: for the minutes of incidence [scrupula incidentiæ] (as his method prescribes) admit no more time than 1^h 34^m, and confine the whole duration within 3^h 9^m. Let us learn from the record [Historiâ] of the event what the sky actually showed.

At Goes [GOVZAE], Lansbergen [Lansbergius] writes that he obtained the beginning at $4^{\text{h}} 35^{\text{m}}$, the middle at $6^{\text{h}} 12^{\text{m}}$, and the end at $7^{\text{h}} 49^{\text{m}}$; so that for him it lasted $3^{\text{h}} 14^{\text{m}}$, with, as he writes, 10 digits $37'$ [10.37'] in all.

At Valentiola [VALENTIOLAE], the Cluniac Benedictines who live there, together with other inhabitants, noted the beginning a quarter of an hour after sunset — that is, at $4^{\text{h}} 38^{\text{m}}$ after noon — just when the Moon had lifted itself above the distant hills toward Digne [Diniam]. When I heard this afterward, it gave me a sufficiently certain moment for the beginning. The whole time lasted exactly three hours.

So the end there came at $7^{\text{h}} 38^{\text{m}}$, and the middle falls at $6^{\text{h}} 8^{\text{m}}$ — at least as far as I could learn.

At Digne [DINIAE], where a good many of our people had gone out beyond the town across the river Bléone [Bledonam], the beginning was judged to be at about $6^{\text{h}} 40^{\text{m}20}$, which certainly agrees with the Valentiola observation TO A MARVEL [CONSPIRAT AD MIRACVLVM]. The end was clearly fixed at about $7^{\text{h}} 42^{\text{m}}$, and in any case before $7^{\text{h}} 45^{\text{m}}$. The middle was therefore at $6^{\text{h}} 11^{\text{m}}$, or $6^{\text{h}} 12^{\text{m}}$ at most — as far as we were able to estimate.

At Franeker [FRANICARAE] in Friesland, Metius [Adriaan Metius] writes that he observed the beginning, as exactly as he could, at $4^{\text{h}} 42^{\text{m}}$. This agrees with the Goes, Valentiola and Digne observations as if by prior arrangement [velut ex condicto]; yet he expresses the remaining phases according to the Tychonic calculation, which we have already called erroneous — and that calculation drags so great a man, inattentive to himself, into so shameful an error.

At Prague [PRAGAE], Kepler [Kepplerus] writes: "We were using (he says) the Tychonic clock. The start of its running was arbitrary. We also employed the large quadrants, to note the arrivals of stars at the meridian. The place of the Sun was $17^{\circ} 48'$ of Sagittarius." So when that clock showed $5^{\text{h}} 30^{\text{m}21}$, Markab and Scheat of Pegasus [Marchab & Scheath Pegasi] were on the meridian; from which the hour is derived as $5^{\text{h}} 38^{\text{m}}$, a difference from the clock of about 13 minutes. Again, when the same clock showed $8^{\text{h}} 51^{\text{m}}$, the bright star of Aries was on the meridian, which gave the true hour as $8^{\text{h}} 38^{\text{m}}$: once more, see, a discrepancy of 13 minutes. In this way he reconciles the clock's readings with the sky.

Therefore at $5^{\text{h}} 35^{\text{m}}$ by the clock — that is, $5^{\text{h}} 22^{\text{m}}$ by the sky — the beginning proper [Merum initium] is recorded.

By the clock $6^{\text{h}} 56^{\text{m}}$, that is, in reality $6^{\text{h}} 43^{\text{m}}$: "The circle, on the other side, was inclining toward the horn of Taurus and Capella." So it was still about 10 minutes of time short of the middle.

²⁰so printed; the middle at $6^{\text{h}} 11^{\text{m}}$ and the agreement with the Valentiola observation imply an hour of 4

²¹so printed; the stated difference of about 13 minutes does not close against the derived $5^{\text{h}} 38^{\text{m}}$

By the clock 7^h 7^m, that is, at 6^h 53^m, as Kepler himself puts it: "This circle was advancing at its middle position between the shoulders of Erichthonius [Erichthonij], toward the pole star. So, about the middle."²² Rightly so: for the middle was then either in progress or certainly over — which is a remarkable agreement with the course traced above. All in all, then, from the beginning to this middle there elapses a time of 1^h 31^m, no more, perhaps somewhat less; and this agreement of Kepler's duration with mine is astonishing.

From this middle to the end the same amount of time must be understood, so that the end fell at 8^h 24^m by the sky. Kepler, however, prolongs it by a full 10 minutes, and marks it at 8^h 34^m. We understand the cause of this difference to be the penumbra, which we discussed in the preface: so nothing here disturbs or alters what is certain on other grounds.

Meanwhile, however, it would follow from these figures that Prague is 41 minutes [of time] distant from Digne, whereas I have asserted only 38. But if we allow that even the slightest misjudgement crept into Kepler's determination of the culminations (as I have likewise pointed out), nothing will stop us from admitting that the agreement among all of us is remarkable.

The calculation of my Atlantic Tables gives the beginning at Goes [Gouzæ] at 4^h 34^m; at Valentiola at 4^h 39^m; at Digne at 4^h 41^m; at Franeker at 4^h 42^m; and finally at Prague at 5^h 20^m at most. It gives the middle, too, at Valentiola at 6^h 10^m, at Digne at 6^h 12^m, at Prague at 6^h 50^m — so that the calculation answers the sky with complete exactness. WHICH I HAVE UNDERTAKEN TO DEMONSTRATE [QVOD SVSCEPI DEMONSTRANDVM].

The Tyconic calculation gave the middle of the eclipse [deliquij] at Hven [Huennæ] at 6^h 56^m, as we have seen; but the actual middle did not go beyond 6^h 36^m. That is an inexcusable error of 20 minutes.

IN THE SAME YEAR 1601 [EODEM ANNO 1601.]

AN ECLIPSE OF THE SUN [ECLIPSIS SOLIS] occurred on 24 December, observed at Goes, at Bergen in Norway [Bergis Noruegiæ], at Prague and elsewhere; it is to be brought to calculation by me elsewhere. Tycho weighed it against his own calculations: in the Appendix to his *Progymnasmata* it is reported to have been seen "with some slight discrepancy" [cum aliquantulâ discrepantiâ]. And let this be the end of Tycho's solar eclipses; those of our own century we shall give separately.

ECLIPSE OF THE MOON III [ECLIPSIS LVNÆ III.] — THE 23RD OF MY LIFETIME [ÆUI MEI 23.]

In the year 1602, on 4 June, in the evening [Anno 1602. die 4. Iunij, vesperè.]

At Prague [PRAGAE], Kepler observed the end of the eclipse as follows. "I had the Tyconic clock at hand (he says), showing minutes and seconds. Its run having been started at an arbitrary point, I adjusted it to the altitude of

²²Erichthonius is the constellation Auriga.

the setting Sun, $4^{\circ} 40'$. So the true hour was $7^h 24^m$. At $7^h 58^m$: sunset by calculation, as also by proportional reasoning from the altitude noted earlier; the Moon rose in thick clouds. At $8^h 43^m$: the first trace of the Moon's light was seen. At $8^h 54^m$: a sextant [sextans] of the Moon's round circumference was missing. At $9^h 0^m$: it had not yet entirely ended. At $9^h 2^m$: the circumference was seen, but pale. The eclipse surely ended one minute later, that is, at $9^h 3^m$. The Tyconic calculation gave the end at $9^h 19^m$, and that by way of the hourly motion [Horarium], the equation of time, the semidiameters of the Moon and of the shadow, and the difference of meridians between Prague and Hven as established by Tycho — all of which can be changed while the hypothesis, which represents the very moments of the oppositions, is kept intact."

So Kepler. His language, as is evident, is full of despair, because he sees Tycho's calculation differ from the sky by so enormous a gap.

My Atlantic calculation [Calculus meus Atlanticus] gives the end of this eclipse at Prague at $9^h 5^m$ after noon; and, without any equation of time, by means of the oscillatory prosthaphaereses of the Moon, I satisfy this observation within the narrow limits of one minute, or two at most — a precision scarcely attainable by any human effort. WHICH WAS TO BE DONE [QVOD ERAT FACIENDVM].

ECLIPSE OF THE MOON IV [ECLIPIS LVNÆ IV.] [RECTE: ECLIPSIS] —
THE 24TH OF MY LIFETIME [ÆUI MEI 24.]

In the year 1602, on 29 November, in the morning [Anno 1602. die 29. Nouembris, manè.]

At Valentiola [VALENTIOLA] (where I was then living), as I was setting out for Aix [Aquis-Sextias] together with other travellers, when we were not far from Vinon [Vinonio], the eastern limb of the Moon suddenly began to grow dim and to be blunted, and soon even to fail entirely. But just as the eclipse [Deliquium] was beginning, the Moon was snatched from our sight by a mountain standing in the way beyond the Durance [Druentiam]. I then regretted both the trust I had placed in the calendars, which had cheated us of this spectacle, and the needless journey: at home, with a freer horizon, I could have enjoyed watching it for longer. So this eclipse alerted me to a manifest error in the calendars, and fired me with the hope and desire to take more care in future.

As for the rest: from the spot where we had stopped, a quarter of a Provençal league [leucæ Prouincialis] still remained to Vinon [Vinonium], which we covered in about 18 minutes of time [minutis circiter horariis 18']; and as we came up to Vinon the Sun rose there, at $7^h 29^m$. So I can state with fair confidence that the eclipse began there at $7^h 11^m$ [horâ 7.11.], and at Aix at $7^h 10^m$, quite precisely.

My Atlantic calculation [Calculus meus Atlanticus] gives the beginning of this eclipse at Aix at $7^h 10^m$, so exactly that no mortal ought to demand

anything more scrupulous. No equations were applied at all, only the oscillatory prostaphaereses [Prostaphæresibus Oscillatoriiis] — and see, I have accomplished the whole thing. WHICH WAS TO BE DONE [QVOD ERAT FACIENDVM].

Origanus — that is, the Tychonic calculation — would put the beginning at Aix only at 7^h 30^m: an error of 20 minutes of lateness, far too enormous.

ECLIPSE OF THE MOON V [ECLIPSIS LVNÆ V.] — THE 25TH OF MY LIFETIME [ÆUI MEI 25.]

In the year 1603, on 24 May, in the evening [Anno 1603. die 24. Maij Vesperè.]

At VALENTIOLA [VALENTIOLAE]. The Benedictines had carefully set their striking clock [horisonium] by the sundials [Sciotherica] before sunset, and I had with me a learned young man, Godemarus [?] of Digne [Godemarus Diniensis] (afterwards an advocate [causarum postea Aduocatus]), who, to keep me company at Valentiola, had become my room-mate and even shared my bed. We noticed the beginning of the eclipse right at a quarter past ten [sub ipsum quadrantem à decimâ]. We judged the greatest defect to be 8 digits; and when the Moon was already culminating, the clock struck twelve — so close was its agreement with true time. At that moment the Moon was depressing its eastern horn and raising its western one, and it had readily recovered half a digit of fuller light. When one o'clock struck it was not yet restored; so little was lacking that it appeared whole only at 1^h 2^m. Thus the middle of this eclipse at VALENTIOLA [VALENTIOLAE] was at 11^h 38^m, most precisely; and the whole duration lasted 2^h 48^m, no more. I took care here, and I am sure I did not err by even a minute.

At GOES [GOVZAE], Lansbergen [Lansbergius] foists on us a middle found at 11^h 56^m, when it cannot have exceeded 11^h 32^m, or 33^m. He gives the digits as 7 digits 30' [Digitos prodit 7.30']. All of it from his own Tables. I believe that he is either deceiving us [fucum nobis facere], or relied on striking clocks [horisoniis], or at any rate reasoned from the end of the penumbra, which would have fallen there at 1^h 20^m.

At PRAGUE [PRAGAE], Kepler [Kepplerus] again used the Tychonic clock [Horologio Tychonico]. When it showed 9^h 12^m 30^s, Arcturus was on the meridian, from which the true hour is gathered as about 9^h 54^m. Thus he adds 42 minutes to the Tychonic times throughout. For in the same way, at clock time [Automato] 10^h 42^m, he assigns the hour 11^h 24^m from the culmination of the head of the Serpent [capitis Serpentis]; and since those stars rise quite high toward the zenith, I dare to trust them. So at clock time 10^h 10^m, that is, at 10^h 52^m: "*The shimmer of the Moon*" (says Kepler himself) "*was broken in my eyes, with the spectacles removed*" [Vibratio Lunæ ... in meis oculis, perspicillis semotis frangebatur]. If, then, the Moon was being broken at that time, that was surely the beginning. This is confirmed by the fact that at clock time 10^h 42^m [Automato 10. 42'.], with the head of the Serpent culminating — that is, at

celestial time $11^h 24^m$ — "*five digits were already missing*" [iam deerant quinque digiti]. The eclipse had therefore begun at least 30 minutes before, at the very least; in any case from the hour $10^h 54^m$.

Again, at clock time $10^h 51^m$, that is, at $11^h 33^m$: "*half was eclipsed*" [deficiebat dimidium]; and at clock time $11^h 9^m$, or $11^h 51^m$: "*half the circumference was missing*" [aberat dimidium circumferentiæ] — that is, above 7 digits $15'$ [suprà 7.15'] of the eight that were to be missing in all. (For on p. 217 of the *Paralipomena* to the *Optics* [Opticorum Paralipomenon] he also plainly states that the edge of the darkened part was seen "*although more than a third part remained*" [quamuis plus tertiâ parte restaret] — that is, more than 4 digits were still shining: "*So the onlookers said that the circle of the dark part was narrower*" [Dixerunt ergo spectatores obscuræ partis circulum angustiores].) This is plainly to be referred to the hour $10^h 52^m$, or 54^m , and the middle belongs to the hour $12^h 17^m$, or 18^m . So the calculations teach, and so the phases around that moment dictate.

For at clock time $11^h 31^m$, that is, at $12^h 13^m$: "*The horns faced the Heart of Scorpio*" [Cornua spectabant Cor Scorpij] — that is, the arc through the centres was carried toward that star. The centre of the shadow was at $3^\circ 8'$ $\nearrow$, and the Heart at $4^\circ 15'$ of the same sign; so the middle was not far off. But at clock time $11^h 43^m$, h. $12^h 25^m$: "*The Moon stood on its back, with its horns lowered equally*" [Luna stabat supina demissis æqualiter Cornibus]. So the middle had already passed. For since the Moon stood $7^\circ 10'$ past the ascending node, the horns had certainly been parallel to the Moon's path for some little while, and the middle had been completed, as I said, at $12^h 18^m$, quite plainly.

Finally, at clock time $12^h 2^m$, at $12^h 44^m$: "*The horns were in a straight line with Jupiter, and the Moon was now rising more to the west*" [Cornua cum Ioue erant in lineâ rectâ; iamq; occidentalius eleuabatur]. Jupiter's place was at 16° Scorpio, with a northern latitude of about $1^\circ 15'$; the Moon's at $3^\circ 8'$ Sagittarius, with a northern latitude of $37' 30''$. But because of parallax it was seen about $15'$ further south than the ecliptic. The horns, seen in this way, were therefore no longer parallel to the ecliptic, and much less to the Moon's own path; and the middle had certainly been completed half an hour before, or even earlier.

At the very end, at clock time $12^h 47^m$, that is, at $13^h 29^m$: "*About a sixth part of the diameter was missing*" [Aberat quasi sexta pars diametri]. So my copy has it $\frac{1}{6}$; van Langren's [Langereni] has $\frac{1}{8}$; others $\frac{1}{7}$; others otherwise. The end must therefore fall at $13^h 40^m$ at the latest; and so the middle is quite plainly to be referred to $12^h 18^m$ [referendum sit in horam 12. 18'] [recte: referendum], and the same duration appears as we also recorded: $2^h 48^m$.

Kepler, treating this eclipse, says: "*The duration is given by Tycho's calculation as $3^h 21^m$; to others it appeared $2^h 52^m$; to me, being dim-sighted [luscitoso], $2^h 59^m$. But with the shimmer*" (of the penumbra) "*which preceded and followed the clean contacts [meros articulos], $3^h 19^m$.*" So long-lasting was that shimmer, evidently after the true end, as was also indicated earlier in the preface. These, then, are Kepler's words — at the hour $1^h 52^m$: "*Something was still missing*"; at 1^h

56^m: "Some thought it had already ended. To me it did not yet seem full"; at 2^h 8^m: "Shimmer, for me, as at the beginning by the clock, 10^h 10^m" [Vibratio mihi, vt Automato Initij 10. 10'] — that is, at true time 10^h 52^m. All of this belongs to the deception of the penumbra [penumbræ fucum]; misled by it, he wrongly assigns even the middle itself to the hour

12^h 30^m — all the more readily, the nearer that value comes to the Tychonic calculation of 12^h 32^m. To indulge that calculation he plainly did violence to the observations. And so the passage already quoted, "About $\frac{1}{6}$ of the diameter was missing" [Aberat quasi $\frac{1}{6}$ diametri], he has in every copy, by applying a knife or a pen, either obliterated or twisted this way and that, so that you cannot tell which of all the readings to approve. At any rate, his aim was to stretch the duration to fit the Tychonic calculation.

Let it stand, then — as what has been said so far sufficiently establishes — that this middle was observed at Valentiola at 11^h 38^m, and at Prague at 12^h 18^m. Let it therefore be certain that between Valentiola and Prague there lie 40^m of hour-time, quite plainly. Between Prague and Digne, accordingly, 38^m; between Prague and Aix, 43^m. This will also be demonstrated elsewhere, with the support of observations made in the following years.

My Atlantic calculation grants this eclipse at Valentiola eight digits, from 10^h 14^m 30^s up to 1^h 2^m after midnight, and places the middle at 11^h 38^m and a very little more. For Prague it sets the beginning at 10^h 54^m, the middle at 12^h 18^m, and the end finally at 1^h 42^m, quite plainly. MY TABLES, THEREFORE, ARE CORRECT. WHICH WAS TO BE DEMONSTRATED.

The Tychonic calculation gives the beginning at Prague at 11^h 8^m, the middle at 12^h 40^m, and the end at 14^h 13^m, according to the true interval between Hven and Prague. Here the difference of the false from the true is 22^m, or (if, with Tycho, we move Prague closer to Hven) at least 14^m — an error far too manifest to be glossed over.

ECLIPSIS LVNÆ VI. Æui mei 26.

Quæ accidit Anno eodem 1603. die 8. Nouembris, Vespere.

Lunar Eclipse VI. The 26th of my lifetime. *Which occurred in the same year, 1603 November 8, in the evening.*

AT DIGNE [DINIAE] it began for us in the evening at about 5^h 52^m; for half a quarter of an hour still remained before hour 6 [Superarat enim Semi-quadrans in horâ 6]. The greatest defect was reckoned at 3 digits. The end was accurately fixed at 7^h 42^m — just as in the year 1601, about three minutes before the last quarter of the hour.

Thus the middle falls at 6^h 47^m, quite precisely.

AT PRAGUE [PRAGAE], Kepler [Keplerus] writes that it began 10 minutes after the right shoulder of Aquarius had culminated, "since already half an hour before, the light was noted growing pale in that part" [Cùm iam ante mediam

horam lumen pallescens, in illâ parte notaretur]. And since the Sun was at $25^{\circ} 55'$ Scorpio, the hour is inferred as $6^{\text{h}} 21^{\text{m}}$ — which in reality was $6^{\text{h}} 30^{\text{m}}$, if my observation at Digne was sound. It is Kepler's habit to anticipate beginnings; or else the error lies in the star, which may have been a different one. "It ended," he says, "three minutes after the Head of Andromeda had culminated": therefore at $8^{\text{h}} 17^{\text{m}}$. On these figures the middle would have been at $7^{\text{h}} 19^{\text{m}}$: "the very minute which Tycho's calculation gives for the meridian of Hven, for the true conjunction in longitude, which differs somewhat from the middle of the eclipse." So he; and shortly after: "To me it was thought that less than a quarter was lacking about the middle; but others maintained that more than a quarter had been hidden. Of the circumference, indeed, less than a third and more than a quarter was judged to be missing. As for the calculation, it agrees entirely with this phenomenon." By these words he hints clearly enough that he had an eye on the Tychonic calculation; and I strongly suspect he made it some concession.

However that may be, the end was noted at Digne at $7^{\text{h}} 42^{\text{m}}$, and the same at Prague at $8^{\text{h}} 17^{\text{m}}$. This shows the difference of the meridians to be at least 35^{m} , and it agrees quite closely with the earlier results. Kepler himself certainly seems to acknowledge that the beginning was ambiguous, since he observes the light growing pale so long beforehand.

Whatever the case, from the end as marked at both places we gather that between Prague and Digne there lie either 35 minutes, as here, or 41, as in the year 1601. With the most exact delimitation, then, we shall hit the mean, and we shall declare 38 minutes to be the legitimate value [igitima] [recte: Legitima, per the book's errata] — as many as we found from the spring eclipse of this same year. Let this now be certain and beyond doubt, as it is in any case true on other grounds, and was sufficiently demonstrated before the Catalogue of Places.

My Atlantic calculation computes for Digne the beginning at $5^{\text{h}} 51^{\text{m}}$, the middle at $6^{\text{h}} 47^{\text{m}}$, with 3 ecliptic digits most precisely, and the end at $7^{\text{h}} 43^{\text{m}}$. Origanus's Tychonic calculation would give $6^{\text{h}} 0^{\text{m}}$, $6^{\text{h}} 54^{\text{m}}$ and $7^{\text{h}} 48^{\text{m}}$ — a discrepancy now somewhat more tolerable.

ECLIPSIS LVNÆ VII. Æui mei 27.

Anno 1605, die 3 Aprilis, Vespere.

Lunar Eclipse VII. The 27th of my lifetime. 1605 April 3, in the evening.

AT FORCALQUIER [FORCALCARI], whose meridian lies roughly midway between Aix and Digne, sunset came for us at $6^{\text{h}} 22^{\text{m}}$; and a quarter of an hour later, quite precisely — at $6^{\text{h}} 37^{\text{m}}$, I say, or 38^{m} at most — the Moon began to be eclipsed. At the seventh hour at least four digits were eclipsed. Clouds followed; through the gaps that opened in them from time to time, at about $8^{\text{h}} 12^{\text{m}}$, I saw the greatest defect, of no less than 11 digits $40'$ — for there remained a very thin rim, certainly no larger than a minute. The horns, moreover, were

parallel to the Moon's path, so I declared [ptonunciaui] [recte: pronunciaui] the middle certain at that time. The rest could not be seen.

AT TÜBINGEN [TVBINGAE], Mästlin [Mestlinus] described this eclipse in a published booklet, and noted that he saw on the Moon a hanging cloud, as if heavy with much rain. If I could get hold of this writing, I could easily convict Lansbergen [Lansbergium] of a delusion: he took the end of the eclipse, which was spurious because of the penumbra, for the genuine one, and so drew out the middle too far beyond its proper limit.

My Atlantic calculation reproduces that observation of mine at Forcalquier MOST ACCURATELY.

ECLIPSIS LVNÆ VIII. Æui mei 28.

Eodem Anno 1605. die 27. Septembris, mane

Lunar Eclipse VIII. The 28th of my lifetime. *In the same year, 1605 September 27, in the morning.*

AT FORCALQUIER [FORCALCARI], I and Scipio Arnaudus [?], then my pupil, observed the beginning at cockcrow [horâ Gallicinij], at 2^h 42^m after midnight, quite accurately, on the sundial [in fcioterico]. At hour 3, no fewer than 3 digits were already eclipsed. At hour 4 the defect was still growing, and it certainly did not much exceed 8 digits. At hour 5, 5 digits were still missing, or a very little more. At 5^h 40^m it ended completely, having lasted

3 clepsydras [clepsydras] at most. For a long while it pleased us to recall the ἰσοψηφίας [Greek: isopsēphia, "equality of number"]²³ of those 3 and 5 with their hours of digits. The middle was quite certainly at 4^h 11^m.

Lansbergen [Lansbergius] thrusts on us his overlong calculations in this eclipse too; according to them he could not have seen the end at Goes [Gouzæ]. So he writes his own refutation.

The Atlantic calculation gives my observation at its own moment, MARVELLOUSLY ACCURATELY [ADMIRACVLVM ACCVRATE].

Moreover, these last two eclipses kindled in me a desire to understand these matters more deeply, and from this year I began to construct Tables for myself, which I afterwards revised many times — yet in such a way that these last two eclipses always remained FUNDAMENTAL for me.

ECLIPSIS LVNÆ IX. Æui mei 29.

Anno 1607. die 13. Martij, vespere.

Lunar Eclipse IX. The 29th of my lifetime. *1607 March 13, in the evening.*

AT FORCALQUIER [FORCALCARI], the Tables promised that the end of the eclipse would still be visible for quite a long time, and so we waited

²³here the coincidence of those figures 3 and 5 with their hours — 3 digits at hour 3 and 5 digits at hour 5, as recorded at the foot of the preceding page

attentively for it. The Sun set at 6^h 12^m, and about 5 minutes later, at 6^h 17^m, the Moon came into view — but already whole. The Atlantic calculation gives exactly this, MOST ACCURATELY.

ECLIPSIS LVNÆ X. Æui mei 30.

Anno 1607. die 6. Septembris, mane.

Lunar Eclipse X. The 30th of my lifetime. *1607 September 6, in the morning.*

AT VALENCE on the Rhône [VALENTIÆ ad Rhodanum] (where my Scipio Arnaudus [?] then was), with many observing, the eclipse began in the morning at about a quarter before the second hour, and ended likewise a quarter before the fourth, having lasted 2^h 0^m. The middle was therefore at 2^h 45^m after midnight. The Atlantic calculation yields 2^h 46^m: AN AGREEMENT MORE THAN MODERATE.

TERTIA ECLIPSIS SOLIS.

Eodem Anno 1605. die 12. Octobris.

The Third Eclipse of the Sun. *In the same year, 1605 October 12.*²⁴

AT FORCALQUIER the Sun began to fail immediately after noon, and continued until 2^h 40^m, so that the middle was at 1^h 20^m. At that time it was so darkened for us that it seemed to fail entirely — except that on the upper limb, toward the north and our zenith, a very fine thread of light remained. I can affirm that this was not any part of the Sun's body, but only the atmosphere, passed through and shining through the air of the Moon, or a second atmosphere [per aërem Lunæ feu Atmosphæram alteram].

For since this greatest defect occurred for me near the nonagesimal, I clearly observed that the Moon, having moved off in a moment from that contact of the limbs, had stood with its limb higher and nearer my zenith than the limb of the Sun. In that imaginary contact, therefore, it did not in fact touch the Sun's limb, but perhaps even exceeded it by a whole minute — only I did not then distinguish this as I do now. But after I had thought these things over with myself more often, and had elsewhere weighed the Sun's optical deceptions at the fringes of the limbs, and had been taught more and more to guard against them, I plainly discovered — with the judgement of others as well — that this eclipse of the Sun had in reality been total. At Marseille [Maffiliæ], indeed, and on the sea near it, the defect was total, with fairly dense darkness.

²⁴the book's errata (p. 130) says of this solar eclipse that it "crept in from my loose notes while I was away" (Eclipsis Solis irrepsit me absente ex Schedis) — which accounts for a 1605 eclipse standing after those of 1607; the printed order is kept.

ECLIPSIS LVNÆ XI. Mei æui 31.

Anno 1609. die 20. Ianuarij, mane.

Lunar Eclipse XI. The 31st of my lifetime. 1609 January 20, in the morning.

AT FORCALQUIER, I, with my Arnaudus and others, observed the beginning at 1^h 10^m after midnight and the end at 4^h 16^m at the latest. The whole duration thus held 3^h 6^m, no more. The middle, therefore, was at 2^h 43^m precisely [omnino].

AT GOES [GOVZAE], Lansbergen observed the beginning at 1^h 5^m and the end at 4^h 15^m. For him, then, the middle fell at 2^h 40^m — which agrees with mine to a hair, within the difference of a single, utterly negligible minute.

AT FRANEKER [FRANECARAE], too, Metius carefully obtained the middle at 2^h 42^m, which likewise differs from my finding by scarcely the slightest amount. This is a striking testimony to its certainty.

The Atlantic calculation answers these TO ASTONISHMENT [AD STV-POREM].

ECLIPSIS LVNÆ XII. Mei æui 32.

Anno 1609. die 16. Iulij, Mane.

Lunar Eclipse XII. The 32nd of my lifetime. 1609 July 16, in the morning.

AT FORCALQUIER the Moon began to fail for us at 9^h 53^m, quite precisely. At hour 10 it was already deficient by more than a digit. It was immersed about two minutes before the eleventh hour; soon clouds followed, with dreadful thunder and fearful lightning.

AT COPENHAGEN [HAFNIAE], Longomontanus [Longimontanus] records in his Catalogue the middle at 12^h 10^m. I believe him, since the whole eclipse was visible there, or at least could have been.

My Atlantic calculation answers all of these WITH ASTONISHING AGREEMENT [CONSENSV STVPENDO] — but at Copenhagen, TO A MARVEL [AD MIRACVLVM].

ECLIPSIS LVNÆ XIII. Mei æui 33.

Anno 1610. die 6. Iulij. Manè.

Lunar Eclipse XIII. The 33rd of my lifetime. 1610 July 6, in the morning.

AT FORCALQUIER the Moon began to fail for us 5 minutes before the third hour, observed with care, and it set while still deficient. The Atlantic calculation gives that beginning at 2^h 55^m — AN ADMIRABLE AGREEMENT [CONSENSIONE ... ADMIRABILI], I would call it, if someone else had also observed it with me elsewhere.

ECLIPIS [recte: ECLIPSIS] LVNÆ XIV. Æui mei 34.

Anno 1610. die 30. Decembris, Mane.

Lunar Eclipse XIV. The 34th of my lifetime. *1610 December 30, in the morning.*

AT FORCALQUIER [FORCASCARII] the beginning of the eclipse came a little before 2^h 40^m; it ended about 4^h 50^m, so that the middle was at about 3^h 45^m. I cannot pronounce on these moments with more confidence, because of clouds.

The Atlantic calculation gives 3^h 44^m — quite EXCELLENTLY [fatis EGREGIE].

ECLIPSIS LVNÆ XV. Æui mei 35.

Anno 1612. die 14. Maij, Vespere.

Lunar Eclipse XV. The 35th of my lifetime. *1612 May 14, in the evening.*

AT LIÈGE [LEODII] (where I had arrived that day on my way back from France), I judged that the eclipse began at about 8^h 37^m. The end came, quite unmistakably, at 11^h 15^m. The duration was 2^h 36^m, scarcely more. The middle therefore fell at 9^h 56^m precisely [admodum], with about 6 digits 30' eclipsed.

I have not yet had the chance to see the Roman observation that Johannes Remus [Ioannes Remus], physician and mathematician, made there.

AT MUNICH [MONACHII], Scheiner [Schemero] judged the beginning to have been *about half a quarter-hour before the ninth hour of the evening; it ended at the twelfth hour itself. Thus it exceeded the calculation in magnitude just as in duration: for it was at least eight digits.* So he says. He differs from me because he counted the penumbra as part of the shadow. For elsewhere, too, at Copenhagen [Hafniæ], Longomontanus, with four other students assisting, found no more than six and a half digits. From Scheiner's words we derive the middle at Munich at 10^h 26^m, which is exactly enough the same [exactè fatis idem est] as my own at Liège: at least it does not diverge by two minutes — for it should have been 10^h 24^m, if I was right.

My Atlantic calculation [Calculus meus Atlanticus] [recte: Atlanticus] gives that middle at Liège at 9^h 56^m. EXACTLY, TO A MARVEL [ADMIRACVLVM PARTILITER].

ECLIPSIS LVNÆ XVI. Mei æui 36.

Anno 1612. die 8. Nouembris, Vespere.

Lunar Eclipse XVI. The 36th of my lifetime. *1612 November 8, in the evening.*

AT INGOLSTADT [INGOLSTADII], Scheiner [Scheinerus], about half a quarter of an hour before the fifth hour, saw *the whole globe of the Moon, but tinged with a blood-red and black colour; and its upper parts were still wrapped in darkness, so that the Moon shone through only very faintly. As the fifth hour struck, these wrappings were dissolving; but this struggle of light and darkness lasted almost*

three quarters of an hour, until, a little after half past five in the evening [paullò pòst mediam sextam vespertinam], the Moon smiled out clear. These remnants of the eclipse lasted almost 40 minutes [40. pænè scrupulis]. So, more or less, Scheiner.

AT MACAO [MACAI], this same eclipse was observed by Father Vremanno [?] [Patre Vremanno] of the Society of Jesus from 8^h 30^m to 11^h 45^m. It is indeed useful for establishing the longitude of Macao; but for what I am doing here it does nothing, unless the longitude of Macao itself has first been established. The bridge, as it were, stands on the far bank.

My Atlantic calculation shows the end at Ingolstadt at 5^h 0^m, as exactly as could be wished — WITH AN AGREEMENT ADMIRABLE BEYOND BELIEF [CONSENSV SVpra FIDEM ADMIRANDO].

ECLIPSIS LVNÆ XVII. Æui mei 37.

Anno 1613. die 28. Octobris. Vespere.

Lunar Eclipse XVII. The 37th of my lifetime. 1613 October 28, in the evening.

AT EMDEN [EMDAE] in Friesland, or near it, David Fabricius [Dauid Fabricius] observed the whole later struggle of the eclipse, from the emersion to the full restoration [ab Emerfione ad Repletionem]. Origanus's *Ephemerides*, computed from the Tychonic calculations, had promised that this would last 1^h 12^m 33^s, and that only its later part would be visible in Friesland. Fabricius found as follows: *the Moon's diameter* (Origanus's 32' 0") *far smaller, and the durations of eclipses much shorter, than had hitherto been believed.*

My calculation shows everything as one could wish, and in accordance with the observation of Fabricius, — the Moon's [D] diameter no more than 28' 40", and the struggle only 1^h 4^m 25^s, all of it visible there — WITH EXCELLENT AGREEMENT [CONSENSV EGREGIO].

ECLIPSIS LVNÆ XVIII. Æui mei 38.

Anno 1614. die 24. Aprilis. Mane.

Lunar Eclipse XVIII. The 38th of my lifetime. 1614 April 24, in the morning.

AT LOUVAIN [LOVANII] and AT MECHELEN [MECHLINIAE], the beginning of the eclipse was seen by watchmen and travellers, in both places as the third hour was striking. The Moon, however, set while still eclipsed. This beginning has, it is true, only the testimony of striking clocks [Horifoniis], which is trivial in itself; but where places so far apart agree as one, it is no longer trivial.

My Atlantic calculation gives Louvain 3^h 1^m. EXCELLENT AGREEMENT [EGREGIO CONSENSV].

ECLIPSIS SOLIS huius fæculi VI.

Anno 1614. die 3. Octobris post meridiem.

Solar Eclipse VI of this century. 1614 October 3, in the afternoon.²⁵

IN FRIESLAND, near EMDEN [IN FRISIA circa EMBDAM], David Fabricius observed this eclipse, and noticed that it was both greater than the Tyconic calculation would give and that it had come earlier.

AT ANTWERP [ANTVERPIAE], Michael Coignetus [Michiel Coignet], the celebrated mathematician, found the same. I will deal with these observations elsewhere; let it be noted here only in passing that my calculation achieves exactly this, NOTABLY [NOTABILITER].

ECLIPSIS LVNÆ PEREGRINA.

Anno 1616. die 3. Martij.

A Lunar Eclipse Observed Abroad. 1616 March 3.

Origanus computed the end of the eclipse at FRANKFURT AN DER ODER [FRANCOFVRTI ad Oderâ] at about 3^h 51^m in the afternoon [hora promeridianâ 3.51'fermè]²⁶. That end was observed AT GOA [GOAE] 4^h 2^m later [horis 4.2' feruis] [recte: ferius], namely at 7^h 53^m after noon, as

Kircher [Kircherus] [Athanasius Kircher] attests in his *Magnes*. If we had the meridian of Goa [Meridianum Goënsfem] established, I would use it to confirm my Atlantic calculation. As it is, working [Greek: ἄνω ποταμῶν (anō potamōn, "upstream" — i.e. the other way round)], I compare that Goan observation against the calculation, and (if I can) establish the longitude of Goa — and so confirm it as it is set down, not badly, on certain maps.

My calculation, then, gives the end of this eclipse on the Atlantic meridian at 1^h 30^m 30^s, and at Frankfurt an der Oder [Francofurti verò ad Oderam] at 3^h 58^m at the most. The true longitude of Goa therefore lies 6^h 22^m east of the first meridian; that is, 2^h 41^m further east than Cairo [Cahiro].

ECLIPSIS LVNÆ XIX. Æui mei 39.

Anno 1616. die 27. Augusti. Mane.

Lunar Eclipse XIX. The 39th of my lifetime. 1616 August 27, in the morning.

AT LIÈGE [LEODII] various striking clocks [Horifonia] could be heard through the city, and though they did not agree well with one another, they nonetheless turned out to be very convenient for marking the phases, once I had compared them with the culminations of stars once, a second time and a third time. I noted the beginning of the dimming of the limb at 1^h 20^m after

²⁵the book's errata (p. 130) says this solar eclipse "was likewise inserted against my intention" (cf. the solar eclipse on p. 77); the printed text is kept.

²⁶so printed; *promeridianâ* would mean "forenoon", but the same sentence makes 3^h 51^m + 4^h 2^m the Goa time of 7^h 53^m *after noon*, so the afternoon (*pomeridianâ*) is meant

midnight, or 21^m at most. The true beginning [Merum initium] was at 1^h 23^m, and at 1^h 28^m one digit was already eclipsed. The Moon was immersed at 2^h 42^m, and a little after, about a minute having passed, the half of the third hour [Medium tertiæ] struck in the Palace. It began to emerge as the Palace clock began to strike the third hour; from the culminations, that moment was certainly 3^h 13^m of celestial time, precisely. When the same clock showed 4^h 15^m, the Moon was still eclipsed by a full half-digit [amplo femidigito]; it was restored [Repletus] at 4^h 18^m by the Palace clock, which was 4^h 31^m celestial, accurately enough — except that some shadowiness [vmbraginis] still remained until 4^h 33^m.

The whole duration could have been judged, from the tinge [fuco] of the shadow, at 3^h 12^m or 13^m; in reality, however, it did not exceed 3^h 8^m. The stay in darkness [Mora in tenebris] lent itself very well to measurement: 31 minutes, not much less. The middle came at different times by different clocks; by the Palace clock it fell at 2^h 44^m 30^s, precisely enough. This is therefore to be referred to celestial time 2^h 57^m 30^s, most exactly, or at any rate not much less.

AT TÜBINGEN [TVBINGAE], Mästlin [Mefthlinus] observed the beginning at 1^h 33^m, by the altitude of Orion's right shoulder, and the end at 4^h 43^m, by the altitude of Sirius. For him, then, the duration was 3^h 10^m, and the middle falls at 3^h 8^m. Its agreement with my observation is astonishing [stupendus]; and it separates Tübingen from Liège by 11 minutes, just as all the most recent maps also show.

AT ROME [ROMAE], Grunbergius [Christoph Grienberger] observed the beginning at 1^h 43^m 30^s and the end at 4^h 56^m 24^s. It therefore lasted about 3^h 13^m, entirely as I too noted, and the middle was accordingly at 3^h 20^m. So the difference between the meridians of Rome and Tübingen is 12 minutes, and between Liège and Rome 23 minutes, quite plainly.

AT ROME again, others, separately and in another house, using a telescope [Telescopio], reported the moment of incidence [momentum incidentiæ] at 3^h 6^m 30^s and of emersion at 3^h 33^m 45^s; hence a stay in darkness of 0^h 7^m 15^s [Hor. 0.7' 15"]²⁷, and the same middle as the other observer, 3^h 20^m. This agreement is admirable, and it confirms the reliability of the meridians already given.

AT LINZ [LINCII], Kepler [Kepplerus] judged the beginning at 1^h 48^m, and the end at the very setting of the Moon: *"When the Sun already had an altitude of 1° 20', and both luminaries were seen in the meridian semicircle of the horizon — so much so that he was in doubt whether, at the very setting of the Moon, something was still lacking to the fullness of its light, or whether a dulling of the light caused by the Earth's penumbra gave a false appearance of eclipse through the thick air, already shining with the brightness of day. The Sun rises at Linz on the said day at 5^h 14^m."* So Kepler, who assigns the middle to 3^h 30^m [horo 3.30']. But if the Sun

²⁷so printed; the incidence and emersion times just given differ by 27' 15"

was already raised $1^{\circ} 20'$ above the horizon, then it must surely have been $5^h 20^m$ exactly when the eclipse ended. The middle falls at $3^h 34^m$. Linz therefore lies east of Liège by 37 minutes at most; of Tübingen by 26 minutes, and of Rome by 14 minutes exactly [omninò]. These values will soon be confirmed by one observation after another.

This duration at Linz is $3^h 32^m$; Kepler himself, however, makes it $3^h 28^m$, and he ends it with the hour of sunrise, $5^h 14^m$ — forgetting that the Sun had stood $1^{\circ} 20'$ high. Yet he blames so great a duration — longer than ours and Mästlin's [Mæftlinianâ] by so wide an interval — on the conditions or faults of vision, about which he has testified in his *Optics* [Optica], p. 218. "Let it nevertheless be ended," he says, "4 minutes before sunrise" — that is, at $5^h 10^m$ — "and the middle at $3^h 30^m$; the difference of the meridians of Rome and Linz would then be 10 minutes." So Kepler, his conjecture uncertain, his correction doubtful. The middle will certainly be at $3^h 34^m$ [Ita ille diuinatione omni ad Mediũ erit 3.34' dubiâ, correctione incertâ] [recte: diuinatione incertâ, correctione dubiâ. Omnino Medium erit, per the book's errata]. For in reality he counted [accēfuit] into the eclipse the penumbra, both of the preceding [Greek: προσκοτίας (proskotias, gen. of προσκοτία, "fore-darkening")] and of the following [Greek: ἐπισκοτίας (episkotias, gen. of ἐπισκοτία, "after-darkening")], about 12 minutes on either side. So in place of $3^h 8^m$ for the whole duration he had $3^h 32^m$, and in reality the middle at Linz was at $3^h 34^m$, as we said.

He records no stay in the shadow, because he believed there was none, together with Mästlin [Mæftlino]. Accordingly, dealing with this same eclipse in his *Tables*, p. 103, he says: "Of the observers, some assert that it was total, others partial; so great is the diversity of eyes, so differently do eyes judge." My eyes, certainly, observed those 31 minutes clearly and distinctly, without any telescope, even though the Moon was glowing quite plainly.

My Atlantic calculation shows all these middles, and my stay in darkness as well, MARVELLOUSLY [AD MIRACVLVM].

ECLIPSIS LVNÆ XX. Æui mei 40.

Anno 1617. die 16. Augusti, Vespere.

Lunar Eclipse XX. The 40th of my lifetime. 1617 August 16, in the evening.

AT HERK [HERCII], everything was carefully prepared and learned men were called in, among them Dominus Petrus Reinart, pastor of Donk [?] [D. Petro Reinart Paftore Doncano]. The Moon began to emerge straight away from $8^h 15^m$. At $9^h 15^m$ something was still missing. It was finally restored at $9^h 17^m$ at most. The bright star of the Vulture [Lucida vulturis] stood about $7^{\circ} 30'$ before the meridian.

AT LINZ [LINCII], Kepler, in a company of nobles [in coronâ Procerum], found more than three-quarters [plus dodrante] in the shadow when the seventh

hour had already struck through the town — that is (with the clock corrected by the azimuth and the altitude of the Moon), when it was 7^h 14^m of celestial time. Since, then, a little before, there had already struck the seventh hour, the town moment [momentum vrbicum] must indeed have been 7^h 3^m. So 11 minutes had to be added to the striking clock [horisonio] — or, as Kepler himself understands it, about 10. Exactly three-quarters [dodrans ipsissimus] of the Moon was therefore eclipsed at 7^h 0^m town time [horâ Vrbicâ], 7^h 10^m celestial time. It shone out again at 9^h 0^m town time, when it had recovered a quarter of its light — that is, at 9^h 10^m celestial time. The middle, then, was at 8^h 0^m town time, which was 8^h 10^m celestial time at most. Next, at 9^h 15^m by the striking clock, that is 9^h 25^m, half the circle less half a diameter was shining. At 9^h 30^m by the striking clock, that is 9^h 40^m celestial time, three-quarters was shining. Finally, at 9^h 45^m by the striking clock, that is 9^h 55^m, a quarter of a digit was still in the shadow; and a little later, at 9^h 56^m celestial time, the Moon was seen whole.

It follows that between Herk [Hercium] and Linz [Lincium] there are 39 minutes of time at most. This agrees perfectly with the earlier observation, which put Liège [Leodium] 37 minutes west of Linz; for Herk lies west of Liège by 2^m 15^s [minutis 2. 15'], determined quite accurately.

My Atlantic calculation represents these observations as exactly as we could expect EVEN FROM A MIRACLE [VEL A MIRACVLO].

ECLIPSIS LVNÆ XXI. Æui mei 41.

Anno 1619. die 26. Iunij.

Lunar Eclipse XXI. The 41st of my lifetime. 1619 June 26.

The ephemerides promised an eclipse of three digits, lasting 2^h 14^m, from eleven o'clock until past one after midnight. Since I expected to be away from my house at Herk [Hercanâ ... domo], I had entrusted the observation to my brothers and to other young men, in case — as happened — I should not be free for it.

AT HERK [HERCII], then, they waited from the predicted beginning onward until midnight, and nothing of an eclipse appeared. But after the Moon had culminated and midnight had passed, the northern limb was seen to be faintly dulled. Yet the expected quantity never appeared anywhere: only a doubtful kind of soot clung to that edge, and all of it vanished at one o'clock exactly [cum ipsâ primâ]. If, therefore, there was anything from which they could suspect an eclipse, it must have fallen in the middle of the first hour. When I returned home I was astonished at so unexpected a report. Yet it did not then occur to me that the Moon had been higher above the Earth than the Tables allowed. Instead I judged either that the shadow, cut short by refractions [Rerfactionibus] [recte: Refractionibus], had thinned the eclipse; or that the Moon's distance from the nodes needed correcting; or, finally, that the latitudes

at the syzygies [in Copulis] are larger — a view I afterwards saw that Kepler [Kepplero] favoured.

ECLIPSIS LVNÆ XXII. Æui mei 42.

Anno 1619. die 21. Decembris. Mane.

Lunar Eclipse XXII. The 42nd of my lifetime. *1619 December 21, in the morning.*

AT MECHELEN [MECHLINIAE] (where on that day I was to receive the sacred order of the subdiaconate), the Moon began to be eclipsed at 1^h 27^m after midnight, when Canis Major [Canis maior] had passed the meridian by not yet one degree. The end was at 4^h 28^m at most. For when Dubhe [Dubbe] stood one and a half degrees before the meridian — that is, by no more than 3° 25' of equator degrees [temporibus], with 247° 31' of the equator culminating — the eclipse had already ended about a minute and a half earlier; and at that same moment, as it happened, the clock was striking 4^h 30^m. So the whole duration was three hours, and the middle fell, in all, at 2^h 57^m 30^s, with a defect of almost eleven digits.

AT HERK [HERCII], my brothers and other novices [Tyrones] noted the beginning at 1^h 30^m, when Canis Major had passed the meridian by one and a half degrees and the clock was just striking 1^h 30^m. It ended likewise when 4^h 30^m was heard striking. Something had gone wrong with the sundial [Scioterico]; but the striking clock certainly gave three hours there too. This was a remarkable agreement between us, and one we looked upon as fit to be kissed [exosculanda], since the middle at Herk also corresponded to about 3^h 1^m, which squares exactly with the Mechelen value: for Herk lies east of Mechelen by 4 minutes in all. They too judged the digits to be fully eleven.

My Atlantic calculation shows these figures at both places MOST ACCURATELY [ACCVRATISSIME].

ECLIPSIS LVNÆ XXIII. Æui mei 43.

Anno 1620. die 14. Iunij. Vesperè.

Lunar Eclipse XXIII. The 43rd of my lifetime. *1620 June 14, in the evening.*

AT AIX [AQVIS-SEXTIIS], Gassendi [Gaffendus] observed the beginning when Spica [fpica] stood 16° 58' high toward its setting, that is, at 11^h 15^m; the immersion when Arcturus was still 35° 34' high, namely at 12^h 27^m. The emersion was not exactly evident, but it seemed to occur when the Crown [Coronâ] was still 37° 15' high, that is, at 14^h 0^m. So the whole struggle [tota lucta] will have lasted 1^h 12^m, and the middle will have been at 13^h 13^m.

AT HERK [HERCII], the clouds begrudged me almost everything. Through occasional gaps in them, however, I snatched a sight of the Moon eclipsed to three digits, at 11^h 27^m after noon [horâ pomediana]. I therefore

judged that the beginning had occurred at 11^h 12^m, and reckoned that the immersion would come at about 12^h 17^m — whether that was true, let Gassendi judge. The emersion began a little before two after midnight, since at two o'clock exactly some small part of the Moon was already shining. The rest was not visible. The middle at Herk therefore falls at 1^h 7^m after midnight.

AT STRASBOURG [ARGENTORATI], Eberhard Welper [Euerhardus Welperus] observed this eclipse and described it in a booklet he published. Although I have used every diligence and written to various people, I have not yet managed to obtain it. At Verona [Veronæ] [?] it lasted (with the penumbra) until 3^h 50^m after midnight. If the 30 minutes of penumbra are taken away, the true end there will have been at about 3^h 20^m.

My Atlantic calculation gives for Herk the beginning at 11^h 12^m, the immersion at 12^h 17^m, the middle at 1^h 7^m, the emersion at 1^h 57^m, and finally the end at 2^h 2^m — which AGREES [CONGRVIT] with the observations.

ECLIPSIS LVNÆ XXIV. Æui mei 44.

Anno 1620. die 9. Decembris, Vesperè.

Lunar Eclipse XXIV. The 44th of my lifetime. 1620 December 9, evening.

AT BRUSSELS [BRUXELLÆ], van Langren noted the emersion when the bright star of Aries [lucida Arietis] stood at an altitude of 51° 12' — that is, at 6^h 25½^m, as he also recorded. He fixed the end when the same star's altitude was 57° 34' — that is, at 7^h 24^m, as he wrote beside it.

AMONG THE BETHASII [BETHASIIS], who lie barely 15 seconds west of Herk [Hercio], the beginning was not visible, because of some clouds on the horizon. From the phases of 5 and 7 digits, however, I inferred the beginning at 3^h 52^m. The immersion was clearly seen at 4^h 51^m, with 329° 45' of the equator culminating. The Moon emerged with 354° 30' culminating, that is, at 6^h 29^m, and the eclipse ended at about 7^h 28^m, with 9° 12' culminating, quite distinctly. The middle, then, was at 5^h 40^m, determined fairly accurately.

My Atlantic calculation represents these observations MOST EXACTLY [EXACTISSIME]. Throughout the whole time the Moon lay hidden in the shadow, it vanished so completely that, although the stars were twinkling very brightly, scarcely anything — indeed hardly anything at all — could be seen of the Moon.

This eclipse was observed in China [apud Sinas]. How much authority it won for our Europeans through the certainty of its prediction can be learned, with the greatest pleasure, from the report of the Fathers of the Society. The beginning at Concincina [Concincinæ]²⁸ was at 11^h 0^m. That place therefore lies 7^h 8^m from the Bethasii, and 9^h 0^m, or 135° 0', from the Atlantic meridian.

²⁸probably Cochinchina

ECLIPSIS LVNÆ XXV. Æui mei 45.

Anno 1621. die 29. Nouembris, Mane.

Lunar Eclipse XXV. The 45th of my lifetime. 1621 November 29, morning.

AT AIX [AQVIS-SEXTIIS], Gassendi had a cloudy sky, through which he judged the beginning at 1^h 54^m, from the altitude of Aldebaran [Aldebaræ], 52° 10'. The end of the eclipse [Finis deliquij] was at 3^h 52^m, when the same star was still elevated 32° 30', and Orion's right shoulder [Humerus ... dexter Orionis] 39° 30' toward the west. The whole duration, then, would have been 1^h 58^m. The middle comes at 2^h 53^m, at which time the digits (so far as they could be estimated through the clouds) were found to be 3 digits 38' [3.38']. "But do not," he says, "trust it too much." In this way he keeps his word [fidem fuam liberat].

AMONG THE BETHASII [BETHASIIS], the first touch of the penumbra on the Moon's limb began, for me, at 1^h 59^m by the sundial [indice Scioterico]; but the true beginning came at 2^h 2^m. The end occurred at 3^h 57^m, though the penumbra lasted beyond 4^h 3^m. The whole duration was 1^h 55^m at most. The middle fell at 3^h 0^m; in my notebooks [in Aduerfaria mea] I entered 3^h 1^m for it — a very slight difference, indeed none. I estimated the digits at exactly three, scarcely more.

AT LINZ [LINCII], Kepler [Kepplerus], under a very turbulent sky, managed to catch the beginning somehow, at 2^h 33^m, from the altitude of the Moon, since he could scarcely make out the Moon, let alone the stars. He noted the end at 4^h 34^m. He therefore declares the middle at 3^h 33^m 30^s, at which time he judged that 4 full digits were gone [abfuiffe]. The duration, for him, was 2^h 1^m.

There is no great difference between us in the duration and the middle. But from the end [fed de fine], we conclude that the distance between Aix [Aquas Sextias] and Linz is about 42 minutes of time; between Aix and the Bethasii, 5 minutes at most; and finally between the Bethasii and Linz, about 37 minutes. For if we bring the end to the test, there will be about 5 minutes between Aix and the Bethasii, and from there to Linz 36^m 30^s [36'30"]; and Linz will be 42 minutes distant from Aix, scarcely differing by the least amount. These results may usefully be compared with the years 1603 and 1616.

My Atlantic calculation represents these observations TO A NICETY [ADVNGVEM].

ECLIPSIS LVNÆ XXVI. Æui mei 46.

Anno 1623. die 15. Aprilis, Mane.

Lunar Eclipse XXVI. The 46th of my lifetime. 1623 April 15, morning.

AT DIGNE [DINIAE], Gassendi noted the beginning at 3^h 9^m, when the tail of Leo [cauda Leonis] was still 20° 6' high. The eclipse certainly did not yet seem to show when Aquila was already 38° high, that is, at 3^h 8^m. "Although,"

he adds, "a difficulty arose because the darkening through the penumbra began on that lower left part, where the spots spread out to the limb make the circumference darker. The end could not be observed, because the Moon set." He declares that it was very nearly 11 digits, and that the remaining portion of the diameter was seen to be equal to the diameter of Jupiter, which he had seen a little before.

AT LINZ [LINCII], Kepler, although the sky was cloudy, nevertheless noticed that the eclipse had begun sooner than expected. For around the middle the Moon shone out with its horns turned upward [cornibus supinis], and it seemed to be about 1 hour from the horizon, so that it was about 4^h 16^m [hora 4.16' admodum]; for the Sun rises there at that season at 5^h 16^m. Now since the horns, which were then parallel to the horizon, were not yet parallel to the ecliptic, and much less to the Moon's path, it will be easy to pronounce on the middle within fairly narrow limits of time. The Sun was at 24° 31' of Aries [printed: 24'.31 ♈]; the Moon was therefore at about 24° 31' of Libra. The Moon, moreover, stood 6° 24' before the Dragon's Head [Caput draconis]. Hence the perpendicular from the centre of the shadow to the Moon's path, and the other perpendicular from the centre of the shadow through the centre of the Moon to the horizon, enclosed an angle of 29 or 30 degrees. The Moon was therefore still about 18½' from the middle, that is, 0^h 34^m or 35^m in time. So the middle at Linz clearly falls at 4^h 50^m at most. Accordingly Kepler himself too, having fixed the middle by his own calculation at 5^h 15^m, judged that an equation of time [æquationem temporis] must be sought that would subtract 19 minutes and more and bring it back to 4^h 55^m, so as to meet the true time.

My Atlantic calculation gives the middle at Digne [Diniæ] at 4^h 14^m, and at Linz [Lincij] at 4^h 53^m [4.53'] — MATCHING CLOSELY ENOUGH [SATIS PARTILITER PARIANS].

ECLIPSIS LVNÆ XXVII. Æui mei 47.

Anno 1624. die 3. Aprilis. Vespere.

Lunar Eclipse XXVII. The 47th of my lifetime. 1624 April 3, evening.

Neither the preceding eclipse nor this one could in any way (however much I lay in wait [tumuis insidiatus]) be made out with my eyes, so persistently was the sky overcast for me. AMONG THE BETHASII [BETHASIIS], however, I noticed that at 8^h exactly [horâ octauâ ipfiffimâ] it had already ended — finished, perhaps, a few minutes before, for nothing remained from which I could suspect even the penumbra.

AT STUTTGART [STVCCARDIÆ], by the striking clock [horifonium], the Moon began to emerge at 6^h 58^m. It was fully restored [Repleta est] at 7^h 58^m, so that this restoration [Repletio] lasted one hour, quite precisely. But Fridericus Ritelius [?] (to whom these phases showed through gaps in the clouds [per interhiantes nubes]), after the emersion had begun, observed Arcturus at an altitude of 20°, so that the time was 7^h 31^m. When 3 digits were shining, the

altitude of Arcturus was $22^{\circ} 45'$, and therefore the time $7^h 48^m$. When 6 digits were shining, the altitude of the same star was about $24^{\circ} 18'$; the time, then, $7^h 57^m$. The upshot of these is that the Moon emerged from $7^h 27^m$ and ended completely at $8^h 27^m$ — if Ritelius took his altitudes correctly. Whoever strikes the mean between these two clocks would say that the emersion began at about $7^h 13^m$ and that the end falls at $8^h 13^m$. Now between the Bethasii and Stuttgart there are 14 minutes [minuta media 14]. So for me the eclipse must have ended at least one minute before 8^h — which agrees excellently with the end, though I did not see it; and it proves beyond doubt some dislocation [luxationem] of Ritelius's quadrant. So much, then, for this eclipse.

My Atlantic calculation assigns the end among the Bethasii to $7^h 58^m$ — IN THE BEST FAITH [OPTIMA FIDE].

ECLIPSIS LVNÆ XXVIII. Æui mei 48.

Anno 1624. die 26. Septembris.

Lunar Eclipse XXVIII. The 48th of my lifetime. 1624 September 26.

AT BRUSSELS [BRVXELLÆ], van Langren [Langerenus] noted six digits eclipsed at $6^h 48^m$, with $285^{\circ} 30'$ of the equator culminating. He caught the immersion at $7^h 18^m 20^s$, when $293^{\circ} 27'$ was culminating; the emersion at $9^h 2^m$, with $319^{\circ} 12'$ culminating; and finally the full restoration [Repletionem] at $9^h 59^m 40^s$, with $333^{\circ} 40'$ then culminating. The stay [mora] in the shadow was therefore $1^h 44^m$. The middle, then, belongs quite precisely to $8^h 10^m$ [horæ 8.10' præciffimè].

AMONG THE BETHASII [BETHASIIS], we noticed the first threats of the eclipse [primas minas deliquij] at $6^h 25^m$, so that by $6^h 28^m$ the defect was noticeable. At $7^h 23^m$ the Moon was already either being immersed or was immersed; but until $7^h 29^m$ a certain secondary light still clung to the immersed limb. At $9^h 7^m$ it was already flashing out as it emerged, and at $9^h 10^m$ it cast as much shadow as if a whole digit had been shining. At $10^h 4^m$ it truly ended, although right up to $10^h 12^m$ an ἐπισκοτία [Greek: episkotia, "overshadowing, darkening"] produced a shadowiness [vmbraginem]. The whole duration was therefore about $3^h 39^m$, and the stay $1^h 44^m$, throughout which the Moon glowed red with a pure brightness, while a light cloudlet rose around the middle. The middle among the Bethasii therefore fell at $8^h 15^m$ at the latest, even though, owing to the deceptive play of the penumbra [ex penumbræ ludibrio], it might have been judged to belong to $8^h 19^m$. But van Langren removed all doubt: the Bethasii are east of Brussels by about $4^m 20^s$ [4'20"], and the agreement between us in the moments is astonishing.

AT LINZ [LINCII], where Kepler [Kepplero] and, in another house, another expert in these matters were observing, the whole duration was found to be no greater than $3^h 38^m$, and its middle was reported at $8^h 55^m 30^s$; the stay, however,

was no greater than $1^h 45^m$, and its middle at $8^h 54^m 30^s$. "So his eyes," says Kepler [Kepplerus], "did not tell him one thing and mine another. The middle is therefore had, within fairly close limits, at $8^h 55^m$." From what has been said, then, the beginning is gathered to have been at $7^h 6^m$ Linz time; the immersion at $8^h 3^m$; the emersion at $9^h 47^m$; and finally the end at $10^h 44^m$. It is evident that Linz is east of Brussels by 44 minutes of time, and of the Bethasii by exactly 40 minutes [40' ipfiffimis] — which agrees with the year 1617.

Moreover, since all the Tables promised both a longer duration and a longer stay, and the event had not answered expectation, Kepler took refuge in an astonishing and incredible excuse: he suspected that the Earth's shadow had been oval, or elliptical, and that the very globe of the Earth was compressed into a cone [compreffum in Conum] and no longer formed a sphere. This is surely the language of utter despair [plena desperationis oratio].

My Atlantic calculation maintains a perfectly round shadow, and represents all these phenomena MOST EXACTLY, TO A MIRACLE AND TO AMAZEMENT [AD MIRACVLVM ET STVPOREM EXACTISSIME].

ECLIPSIS LVNÆ XXIX. Æui mei 49.

Anno 1625. die 24. Martij. Mane.

Lunar Eclipse XXIX. The 49th of my lifetime. 1625 March 24, morning.

AT PARIS [PARISIIS], Gassendi [Gassendus], together with Mydorge [Miodorgio], noted the beginning at $12^h 54^m$, when the Lion's Heart [Cor Leonis] was still $36^\circ 20'$ high. The end, for them, was at $13^h 37^m$, when the northern Scale [Lanx Borea] was already $31^\circ 30'$ high. The whole duration therefore lasted $0^h 43^m$, and accordingly the middle fell at $13^h 15^m 30^s$ after midnight [hor. post mediam noctem]. "The Moon was eclipsed toward the south so slightly that anyone who did not know there was an eclipse could hardly have believed it was being eclipsed. For that reason it was also difficult to catch the first and the last moment of the darkening." So, at any rate, Gassendi, who adds: "The magnitude of the eclipse scarcely seemed to exceed one digit; it certainly fell short of two."

AMONG THE BETHASII [BETHASIIS], right from midnight I set myself to await this eclipse very attentively, since I believed it would be of three digits and would last a full two hours; I was astonished that everything turned out quite otherwise for me. For as I waited a little while, a faint dulling [habetatio] was barely noticed with the naked eye while Spica was crossing the meridian, at $0^h 53^m$ (by the sundial too [etiam in Scioterico]); but in the telescope it did not appear before $1^h 3^m$, when Spica had already passed the meridian by about 3° . Then, intent on the end, I observed it at $2^h 0^m$, while the southern Scale [Lanx austrina] stood quite exactly 4° before the meridian; with the naked eye, however, the Moon could be judged still to be deficient at $2^h 8^m$. Thus the middle falls at $1^h 31^m$ at the latest; or, if my hesitation caused some delay before I pronounced on the matter, let it be $1^h 30^m$ — a moment I venture to affirm as

quite certain. At the time, indeed, the digits seemed to me about 3; yet in my notebooks [in aduerfariis meis] I find not two full digits recorded. The fringed edge of the shadow, of course, creeping into the lower spot of the Moon, gave the eclipse a greater appearance than the true one; and since the thing fell out contrary to the opinion I had already formed, it deceived me [fucum fecit].

My Atlantic calculation gives the beginning among the Bethasii at 0^h

51^m, the middle at 1^h 30^m, and the end at about 2^h 9^m; it agrees well with the phases, and WITH THE MIDDLE, EXCELLENTLY [CVM MEDIO, CONSENTIT EGREGIE].

These last two eclipses at length warned me that not a few things in my Tables needed correcting: the Moon's anomaly; its distance from the Earth (which until then I had set at only 57½ semidiameters); they also dictated to me a far different eccentricity; and they showed that from apogee to perigee there are eight semidiameters of the Earth in all. Finally they also pointed out the nodes of the Dragons [Nodos Draconum]. In fitting all these — to this last eclipse, and to others both earlier and later — it is incredible with what labours, and with how often repeated Tables, I barely, at long last, got my wish, so that I might bless you, reader [quo te lector bearem].

ECLIPSIS LVNÆ SPVRIA.

Anno 1626. die 7. Augusti. Vespere.

A Spurious Lunar Eclipse. 1626 August 7, evening.

The Ephemerides promised a very small eclipse of about half a digit, to last 44 minutes, with its middle at Linz [Lincij] at 7^h 45^m. But Kepler [Kepplerus], watching carefully there from sunset until 8^h 30^m, found nothing missing from the Moon's roundness; indeed at 7^h 45^m he noticed not even a trace of shadow. By my calculation there is no eclipse at all [Nulla est Eclipsis].

ECLIPSIS LVNÆ XXX. Æui mei 50.

Anno 1628. die 24. Ianuarij. Vespere.

Lunar Eclipse XXX. The 50th of my lifetime. 1628 January 24, evening.

AT PARIS [PARISIIS] (as Pétau [Petavius] wrote to me) the beginning was noticed before 7^h 27^m, while those who used a telescope fixed it, from the altitudes of stars, at 7^h 35^m. But since clouds kept coming between and snatching away the view of the Moon and the stars, only the beginning of the darkening and of the stay [Moræ] could be caught accurately, and the end of neither. The beginning of the stay was put at 8^h 34^m. As for the end, he writes as follows: "A little after the end of the eclipse [deliquij] (for the exit from the stay could not be noticed at all), the altitude of Arcturus was 9° 30'. So it was 11^h 7^m, when the end had already passed (how long before is not known). The whole duration therefore did not exceed 3^h 40^m, and perhaps not even 3^h

35^m. The middle was not later than 9^h 17^m, and so it must have occurred some minutes before.”

AT BRUSSELS [BRVXELLÆ], because of continuous clouds and most troublesome snow, nothing certain was evident to me except the end. It may have fallen at 11^h 15^m, since at 11^h 0^m there were still 3 digits lacking at most, and at 11^h 15^m nothing more was noticed except a confused pallor of the penumbra — which, after one minute, at 11^h 16^m, likewise ceased entirely. But whenever the gaps in the clouds allowed, we saw the Moon glowing red like a burning coal, and all but shining [tantumque non lucentem], so that it could hardly be judged an eclipse.

AT AIX [AQVIS-SEXTIIS], from the altitudes of stars, the times were determined thus: the beginning at 7^h 49^m, the immersion at 8^h 48^m, the emersion at 10^h 25^m, and finally the end at 11^h 24^m. The whole duration was therefore 3^h 35^m, the stay 1^h 37^m. The middle is put at 9^h 36½^m quite exactly [omnino]. From that Paris beginning, 7^h 35^m, and this Aix one, 7^h 49^m, Gassendi [Gaffendus] determines that Aix lies east of Paris by 14 minutes — which I know from other evidence to be true as well. But just as that Paris beginning, obtained by telescope, is later than the true one, so the Aix beginning, likewise fetched by telescope, falls later than the true one [alteri item vero postumat], and indeed by no less than 10 minutes. So the true beginning falls at 7^h 39^m, the immersion at 8^h 38^m, the emersion at 10^h 15^m, and finally the end at 11^h 14^m; and hence the middle is accurately due to 9^h 26^m. Indeed, since it is well established that Aix and Brussels lie under the same meridian, and we saw the end at Brussels at 11^h 15^m, the end at Aix was surely the same.

AMONG THE BETHASII [BETHASIIS], my brothers Nicolaus Wendelinus [?] and Ioannes Acanthus [?] caught these phases somewhat more successfully, after a fashion [vtcumque], with the sundial [in Scioterico], although the clouds and snow troubled them no less than they troubled us at Brussels. The beginning, then, occurred a little after 7^h 40^m. At 8^h 0^m, 3 digits were lacking. The immersion followed

8^h 40^m by a very little. The emersion was at 10^h 20^m precisely. Three digits again remained at 11^h 0^m. The end was clearly marked at 11^h 19^m at the latest. So the stay was 1^h 40^m. The whole duration did not exceed 3^h 36^m — as many as were observed at Aix. The middle was plainly at 9^h 30^m, which that Aix figure of 9^h 26^m clearly confirms.

AT PRAGUE [Pragæ], Kepler [Kepplerus], with other learned men, had the beginning after 8^h 27^m by the striking clock [Horifonium], and quite certainly by 8^h 30^m or a very little later. He had six digits obscured a trifle after 9^h 0^m by the striking clock — at 9^h 1^m by the clock, as you might say. The immersion was at 9^h 30^m by the clock, the emersion at 11^h 10^m by the clock; about six digits had been restored by 11^h 30^m by the clock (but he meant to say, and ought to have said, 11^h 40^m). At 12^h 6^m it had not yet ended; Canis Major [Canis maior]

indicated 11^h 55^m. He finally caught the end at 12^h 10^m by the clock, although at its setting [ac occasu] [?] the Moon was still very pale and its fringe still broken. The stay was 1^h 40^m. So the duration there would have been 3^h 40^m, and the middle at 10^h 20^m. Yet when the times were corrected once and again from the altitudes of stars, it was found [deprehenfum*] that 11 minutes had to be taken off the striking clock. The middle therefore falls at the true time of 10^h 9^m [printed "10' 9."].

This agreement of the observations — at Paris, Brussels, the Bethasii and Prague — so close as it is, sufficiently proves the diligence of all of them, and commends my Atlantic Tables, which represent all these moments WITH A MOST EXQUISITE CALCULATION [EXQVISITISSIMO CALCULO].

Kepler, moreover, had computed the stay from his Tables as 1^h 50^m; but he found it at least 10 minutes shorter, and noticed that it did not extend beyond 1^h 40^m. He puts the cause of this discrepancy down to a curtailment of the shadow [ymbræ decurtationem], which he holds to be a regular occurrence [folennem].

ECLIPSIS LVNÆ XXXI. Æui mei 51.

Anno 1630. die 19. Nouemb. Vespere.

Lunar Eclipse XXXI. The 51st of my lifetime. 1630 November 19, evening.

AT BRUSSELS [BRVXELLÆ], through a thoroughly turbid sky, van Langren [Langerenus] noticed six optical digits in the defect, that is, about five true ones, with the bright star of Aries [Lucida Arietis] culminating, at 10^h 5^m 30^s. He judged the greatest defect to be 9 digits 30' optical, 8 true. Then, when 8 digits had been restored and about 4 digits were still in defect, the intersection [fectio] of the Moon and the shadow was culminating, and it was 12^h 3^m [printed "12 3'"].

Let us follow these digits, as they were noted optically and in the Selenography [in Selenographiâ], in order to derive [ernamus] [recte: eruamus] the middle from them. If at 10^h 5^m 30^s six digits were eclipsed, then five digits had been eclipsed at 9^h 57^m, accurately enough. Likewise, if at 12^h 3^m four digits were still eclipsed, then five digits had been eclipsed at 11^h 57^m. The middle therefore falls at 10^h 57^m Brussels time, precisely enough — at least as far as one can understand from this.

AT LEIDEN [LVGDVNI BATAVORVM], Hortensius writes that he observed this whole eclipse from 9^h 22^m to 12^h 23^m, so that it lasted three hours exactly. He therefore places the middle at 10^h 52^m — a full five minutes differently from van Langren [Langerenus], although Brussels and Leiden lie very nearly on the same meridian. That, to be sure, is scarcely any difference worth much regard. He adds that it was a little greater than eight digits — an excellent agreement.

For my Atlantic Tables express the Brussels middle, Hortensius's magnitude and the duration TO A MIRACLE [AD MIRACVLVM].

ECLIPSIS LVNÆ XXXII. Æui mei 52.

Anno 1631. die 15. Maij, Vespere.

Lunar Eclipse XXXII. The 52nd of my lifetime. *1631 May 15, evening.*

AT LYON [LVGDVNI ad Rhodanum], where the King then was, the Moon emerged a little before eight o'clock. It finished filling up with half a quarter-hour [femiquadrante] still left before nine — as I was told by that most learned man Father d'Auxon [Pater d'Auxon], mathematician of the Society of Jesus. He undertook to send me other eclipses observed by himself and by other Fathers in France, all of them timed to exact minutes [ad momenta scrupulosa].

My Atlantic Tables compute the emersion there at 7^h 59^m and the end at 8^h 55^m — ACCURATELY ENOUGH [SATIS ACCVRATE].

ECLIPSIS LVNÆ XXXIII. Æui mei 53.

Anno 1631. die 8. Nouembris, vespere.

Lunar Eclipse XXXIII. The 53rd of my lifetime. *1631 November 8, evening.*

AT MADRID [MADRITI], van Langren, although the sky was obstructed, nevertheless saw at most 4 digits 30' true eclipsed, with the degree 4° 29' culminating — that is, at 5^h 23^m [recte: 9^h 23^m]. The beginning, therefore, had been at about 8^h 59^m 30^s. The immersion took place with the degree 14° 58' culminating, which gives a time of 10^h 4^m 40^s — a difficult observation, as he says, both with the naked eye and through the telescope, because the phase remained doubtful for a long time. The emersion began at 11^h 50^m, for at 11^h 56½^m, when the degree 37° 55' was already culminating, a digit and something more was lit. The end was noted as imminent at 12^h 50^m 12^s, for then, with the degree 56° 27' [printed "56'.27'"] culminating, a little less than 11 digits 30' had been filled. The end, therefore, was at 12^h 54^m, or, as van Langren himself asserted, at 12^h 54^m 40^s. So for him the whole duration was 3^h 55^m 10^s; the whole stay [mora] almost 1^h 46^m; each struggle [Lucta vtraque] lasted 1^h 4^m 30^s. The middle itself falls at 10^h 57^m, or at most 57½^m.

AT PARIS [PARISIIS] the beginning was not seen. The immersion occurred, for Gassendi [Gaffendo], at 10^h 17^m 30^s from the altitude of Jupiter, or at 10^h 22^m 30^s from the altitude of the Moon. Striking the middle between these, the immersion at Paris may be set at 10^h 20^m at most. The emersion was noted when the Moon had indeed already passed the meridian, but when its altitude was taken it showed no other value than if it had then been exactly on the meridian; this time could not have exceeded 12^h 7^m. The middle, therefore, held at about 11^h 13^m.

AT LEIDEN [LVGDVNI Batauorum], Hortensius caught the beginning accurately (as he writes) at 9^h 30^m, the immersion at about 10^h 36^m, the emersion at 12^h 17^m, and finally the end at about 13^h 23^m. For him, then, it lasted 3^h 53^m. The stay was 1^h 41^m; each struggle about 1^h 6^m. The middle at 11^h 26^m 30^s is quite certain.

AMONG THE BETHASII [BETHASIIS], at 9^h 32^m the defect seemed to be starting, but in reality the true beginning followed soon after, at 9^h 33^m; and at the same time clouds took the whole sight of it from me, so that I did not see the immersion either. It began to emerge at 12^h 23^m by the sundial [Scioterici]; the end appeared clearly at 13^h 28^m, and the penumbra lasted until 13^h 36^m. So for me the whole duration was 3^h 56^m at most. The later struggle [Lucta posterior] was 1^h 5^m. The middle, fixed as accurately as was possible, was at 11^h 31^m, and certainly no later. Throughout the whole stay the Moon wasted away in a lurid pallor.

AT TÜBINGEN [TVBINGÆ], Schiccardus [Wilhelm Schickard] did not see the beginning, being hindered by clouds; but by conjecture from the phases he declared that it began at 9^h 46^m. He noted the Moon immersed at 10^h 52^m, and the start of the emersion accurately at 12^h 35^m. He caught the end only with difficulty; yet he writes that at 13^h 42^m nothing more remained except a confused pallor, which usually precedes the true shadow as it arrives and likewise follows it as it departs. He therefore acknowledged the whole duration as 3^h 56^m at most. The middle he fixed at 11^h 43^m, a moment which he judges can hardly be one minute from the truth; otherwise it could be judged to belong to 11^h 44^m.

It follows from these that between Madrid and Leiden there lie 29 minutes, and as many to Brussels; and that from here [Hinc] Tübingen is 17 minutes, no more.

My Atlantic calculation answers the observations TO A HAIR [ADVNGVEM RESPONDET].

ECLIPSIS LVNÆ XXXIV. Æui mei 54.

Anno 1632. die 27. Octobris, Vespere.

Lunar Eclipse XXXIV. The 54th of my lifetime. 1632 October 27, evening.

AT LYON [LVGDVNI ad Rhodanum], Gassendi [Gaffendus] caught the beginning at 10^h 3^m and the end at 12^h 30^m, so that the middle was at 11^h 17^m exactly — from the altitudes of stars, and assuming a latitude of the place of 45° 36′.

AT LEIDEN [LVGDVNI Batauorum], Hortensius writes: *a little after the tenth hour had been heard striking, the Moon suddenly began to grow so pale toward the east that, from the sudden change, someone unaware could have judged it to be in eclipse. But when a telescope was applied, and the quadrant directed toward Jupiter, the*

true beginning was at $10^h 20^m$, when Jupiter stood $41^\circ 36'$ high toward the east, being in $22^\circ 44'$ of Taurus according to Lansbergen's Tables [*ex Lansbergij Tabulis*]. The true end appeared at $12^h 44^m$, with Aldebaran $50^\circ 13'$ high. So for him the duration was $2^h 24^m$, and the middle $11^h 32^m$. The greatest defect was seen to exceed 4 digits 40' only barely, if at all. So much for Hortensius.

AT LIÈGE [LEODII], Otgerus [?], a learned man and a skilled mathematician, at my request devoted careful attention to this observation. He found the beginning at $10^h 18^m$ and the end at $12^h 42^m$ exactly [omnino]; the middle at $11^h 30^m$, most precisely. These moments (the end especially) agree most exactly with Gassendi's [Gaffendi] observations; the duration is plainly the same as Hortensius's.

My Atlantic calculation represents all these moments at Liège, and Hortensius's digits, MOST EXQUISITELY [EXQUISITISSIME].

ECLIPSIS LVNÆ XXXV. Æui mei 55.

Anno 1634. die 14. Martij. Vespere.

Lunar Eclipse XXXV. The 55th of my lifetime. 1634 March 14, evening.

AT MADRID [MADRITI], the beginning was not visible to van Langren [Langereno] because of clouds. When the ascensions gave the hour $8^h 13\frac{1}{2}^m$, 9 digits 33' were eclipsed on his Selenography [in Selenographiâ fuâ]. The greatest defect was 10 digits 15', most precisely. When 9 digits 50' were again eclipsed, the time was $8^h 59^m$. Since, then, the obscuration grew by 0 digits 42' from the first phase to the greatest defect, and from there decreased by 0 digits 25' to the second phase — that is, a change of 67' was made in that intervening time of $0^h 45^m 30^s$ — it is clear that the middle fell at $8^h 42^m$, precisely enough. This is also confirmed by the phase of more than 6 digits 48', though less than the illumination of a semicircle, or 7 digits 15' — that is, of 7 digits 0' in fact — which was seen when degree $137^\circ 23'$ of ascension was culminating, or at $9^h 30^m$ precisely. From this too, therefore, the same middle is confirmed. The end was at $10^h 19^m$ at the latest.

AT AIX [AQVIS SEXTIIS], Nicolaus Fabricius Peireskius [Nicolas-Claude Fabri de Peiresc] had the beginning at about $7^h 33^m$ and the end at $10^h 49^m$, which agrees with the Madrid observation most closely. The middle will have been at $9^h 11^m$ exactly.

AT DIGNE [DINIÆ], Gassendi [Gaffendus] determined the beginning at $7^h 41^m$. He had two digits at $7^h 55^m$, 10 digits at $9^h 2^m$, and the end at $11^h 2^m$. The middle is therefore found to be at $9^h 21^m$ — more than at Aix, whereas it ought not to have exceeded $9^h 16^m$ (if Fabricius [Peiresc] is accurate). But this is to be put down to optical causes, although the discrepancy is almost nil.

My calculation, at $9^h 33^m$, yields the beginning at Aix; the middle at $9^h 11^m$, and at Madrid at $8^h 42^m$; and the end observed here at $10^h 19^m$ and there at $10^h 49^m$ — WONDERFULLY WELL [AD MIRACVLVM BENE].

ECLIPSIS LVNÆ XXXVI. Æui mei 56.*Anno 1635. die 3. Martij. Vespere.***Lunar Eclipse XXXVI. The 56th of my lifetime.** *1635 March 3, evening.*

AT PARIS [PARISIIS], van Langren's father [Langereni pater] noted the emersion at 9^h 23^m, or 9^h 24^m at the latest; the rest was not visible to him.

AT BRUSSELS [BRVXELLÆ], with van Langren [Langereno] observing, it began at 6^h 49^m, accurately enough. At 7^h 7½^m, 4 digits were eclipsed. The end was at 10^h 39½^m, scarcely the least bit later. The middle was at 8^h 44^m 15^s.

AT AIX [AQVIS-SEXTIIS], the beginning was judged to be at about 6^h 48^m, from the altitude of Regulus, 30° 25'; the immersion at 7^h 55½^m, from the altitude of the same star, 42° 10'. The emersion began at 9^h 32½^m, from the same star's altitude of 55° 50'. Finally, the end was at 10^h 38^m, from the altitude of Arcturus, 31° 50'. On this reckoning the eclipse lasted 3^h 50^m in all; the stay [Mora] was 1^h 37^m; and the middle, finally, 8^h 43^m or 44^m. This is the same as van Langren's, quite exactly [fanè quàm partiliter].

AT LEIDEN [LVGDVNI Batauorum], the Moon began to emerge for Golius at 9^h 39^m, from the altitude of Regulus, 41° 3', as he wrote to me.

AT HERK [HERCII], when both the sundial [Sciotericum] and the culminations marked 6^h 53^m for me, the beginning took place, in everyone's judgement. The Moon was immersed at 7^h 59^m, or at the very least a moment before. It emerged at 9^h 40^m. The end, finally, was at 10^h 45½^m, certainly not much later. From these the middle is obtained at 8^h 49^m exactly, which agrees with the Brussels and Aix observations miraculously [ad Miraculum]. And I am certain that I did not err by even a minute, although at the time, suspecting a fading-out [propter Intermorij fuspicionem], I gave the times as a little earlier.

My Atlantic calculation represents these so admirably that I myself am AMAZED AT ITS SUCCESS [FELICITATEM STVPEAM].

ECLIPSIS LVNÆ XXXVII. Æui mei 57.*Anno 1635. die 28. Augusti. Mane.***Lunar Eclipse XXXVII. The 57th of my lifetime.** *1635 August 28, morning.*

AT PARIS [PARISIIS], the most learned Bolialdus [Ismaël Boulliau] judged the immersion to have taken place at 2^h 5^m after midnight, and the emersion at 3^h 40^m; with six digits restored, the time was 4^h 12^m. All of this was from altitudes of Lyra. The middle there will therefore have been at 3^h 53^m, very nearly [admodum].

AT AIX [AQVIS-SEXTIIS], Peiresc [Peireskios] had the beginning without a telescope at [per] 1^h 21^m, from the altitude of Aldebaran, 27° 5', or at 1^h 25^m, from the altitude of the upper limb of the Moon, 22° 15'. With the telescope applied, however, the same beginning was declared some minutes later, namely

at 1^h 30^m or 31^m, from the altitude of Capella and of the Moon. 7 digits were lacking at 2^h 3^m. 9 digits 45' at 2^h 16^m, when the obscuration reached two-thirds of the circumference [bessēm peripheriæ]; that is, there were in fact 10 digits. But 10 digits 45' were observed at 2^h 21^m exactly. Clearly, then, all these taken together fix the true beginning at 1^h 25^m and the immersion at 2^h 25^m — perhaps even earlier, because of the fading-out [intermorium]. And indeed the total immersion is finally marked at 2^h 28^m: *at which time a very slender thread of light is said to have remained, which had already been very thin 4 minutes before.* So, you see, the immersion can be understood as completed even from 2^h 24^m. *The secondary light, in fact, for some while counterfeited the primary,* as Gassendi [Gaffendus] wrote. The emersion was not visible because of clouds. The end was seen with the telescope at 5^h 1^m; with the naked eye it was drawn out to 5^h 5^m. But if the fading-out had the same effect here as at the beginning, the true end will have been even from 4^h 56^m. The middle, therefore, 3^h 11^m.

AT LEIDEN [LVGDVNI Batauorum], Golius writes to me that the immersion was noted at 2^h 25^m, a moment that is the same as the one at Aix.

AT DIGNE [DINIÆ], Gassendi [Gaffendus], struggling with the sky through clouds and continual lightning [per nubes & fulgetra continentia], obtained the following only barely and with difficulty. 5 digits were already lacking at 13^h 54^m. Digits 15' at 14^h 1^m. 7 digits, or somewhat less, at 14^h 4^m at the latest. 7½ digits at 14^h 7^m. All of these come from proper altitudes [ex legitimis altitudinibus], and they show that the beginning there was at 1^h 29^m and that the immersion took place at 2^h 28^m. From this the Aix moments [de momentis Aquenfibis] begin to be all the more firmly established for us.

AT HERK [HERCII], the eclipse began for me at 1^h 29^m: the Navel of Pegasus [ymbilico Pegafi] was not yet culminating, the Wing [Ala] had culminated, and the sundial [Sciotericum] agreed. The Moon was immersed at 2^h 28^m, as the Girdle of Andromeda [Cingulo Andromedæ] attested. The struggle [Lucta] in fact lasted 0^h 59^m exactly. It emerged at 4^h 1^m — barely visible, indeed, but visible all the same. Then at 4^h 20^m 4 digits were shining, and at 4^h 25^m 5 digits, with half the circumference [cum semisse peripheriæ], which agrees most accurately with the Paris observation. The hour for 6 digits was 4^h 30^m. Clouds hid the rest. The middle at Herk [Medium ... Hercanum] was therefore at 3^h 15^m exactly.

AT ROME [ROMÆ], the beginning was visible, after a fashion [vtcumque], at about 1^h 54^m. From the phases at 12^h 45^m and 14^h 33^m, the middle was at 3^h 39^m exactly.

AT CAIRO [CAHIRI] in Egypt, the observation was made by Father Agathangelo [P. Agathangelo; Agathange de Vendôme], a Capuchin, and his companion Ioannes Molinus [?] [Ioanne Molino]. The beginning occurred at 15^h 14½^m, by the altitude of the Moon; the total immersion at 16^h 16½^m, by the same.

AT ALEPPO [ALEPPI] in Syria, Father Caelestinus a Sancta Liduina [P. Cælestinus à S. Liduinâ; Célestin de Sainte-Lidwine], a Discalced Carmelite, and Michael Angelus [Michel-Ange de Nantes], a Capuchin and a skilled mathematician, obtained the beginning at 15^h 28^m, from an observed altitude of the Moon. The total immersion, everything having been carefully weighed, was at 16^h 27^m. So for them, too, the whole struggle [tota Lucta] lasted 0^h 59^m, just as it did for me — which shows how accurate their diligence was. Moreover, the Moon, already hidden within the shadow, was seen for a further whole hour before it set. The Sun rose at 5^h 30^m, so that from this too the observation's reliability is assured.

My Atlantic calculation presents my Herk observation in agreement with those of Digne, Aix, Leiden [Lugdunenfi] and Paris, as exactly [tam partiliter] AS COULD BE WISHED [QVAM OPTARI POTEST].

ECLIPSIS LVNÆ XXXVIII. Æui mei 58.

Anno 1636. die 20. Februarij, Vespere.

Lunar Eclipse XXXVIII. The 58th of my lifetime. 1636 February 20, evening.

AT DIGNE [DINIÆ], Gassendi [Gassendus] observed this eclipse with such success, diligence and certainty that Sirmanus [?] and I named it the QUEEN OF ECLIPSES [REGINAM ECLIPSIVM] — both for that very reason and because whatever can be expected concerning the equations of days [de Dierum Æquationibus] is most conveniently determined by comparing this eclipse with others. I compress the material of a full commentary into a very few lines.

A faint shading [Tenuis inumbratio] began at 9^h 26^m, ever so slightly perceptible.

Time	Observation
9 ^h 42 ^m	<i>The limb could still be made out with the telescope, though with difficulty.</i>
9 ^h 44½ ^m	<i>The limb was growing dark [Obtombreſcebat] in the telescope; hence the beginning.</i>
9 ^h 52 ^m	<i>Half a digit at most seemed to be eclipsed.</i>
11 ^h 26 ^m	<i>Again half a digit was eclipsed, precisely enough.</i>
11 ^h 33½ ^m	<i>Nearly the end.</i>
11 ^h 34½ ^m	<i>At last the end, judged as the beginning was [vt ex Initio iudicatum].</i>
11 ^h 36 ^m	<i>The limb restored whole in the telescope [Redintegratus Teleſcopio Limbus].</i>

A very faint residual shading was last seen at 11^h 51^m. The middle gathered from all of these is therefore, for Gassendi [Gassendo], at 10^h 40^m at the latest; I declare it 10^h 39^m. He also measured the digits carefully: 3 *at most. More precisely. Still more precisely, and in fact no more* [ad ſummum. Magis præciſe, Magis adhuc præciſe, nec reuera ampliùs].

AT BRUSSELS [BRVXELLÆ], van Langren [Langerenus] obtained the beginning at 9^h 38^m, which agrees admirably with the Digne value of 9^h 43^m.

AT AIX [AQVIS-SEXTIIS], the end, awaited with the telescope, came at 11^h 33^m — again in more than moderate agreement.

AT AMSTERDAM [AMSTERODAMI], Hortensius [Hortenſius] obtained the end at 11^h 32^m, which now agrees with Gassendi miraculously [ad miraculum].

My Atlantic calculation gives for Digne:

Beginning 9^h 43^m 30^s; middle 10^h 39^m 15^s; end 11^h 35^m 0^s; with 2 digits 59' [digitis 2. min. 59'], that is, 3 digits 0' exactly [ipſiffimis].

WITH PRODIGIOUS SUCCESS OF THE CALCULATION [PRODIGIOSA CALCULI FELICITATE].

ECLIPSIS LVNÆ PEREGRINA.

Anno 1637. die 31. Decembris. Mane.

A Lunar Eclipse Observed Abroad. 1637 December 31, morning.

AMONG THE HURONS [HVRONIBVS]. In New France [In nouâ Franciâ], Father Castellanus [P. Castellanus; Pierre Chastellain], S.J., observed the middle of this eclipse at 6^h 15^m after midnight.

My Atlantic calculation gives the middle of this eclipse on the Atlantic meridian at 10^h 1^m after midnight, exactly. If, then, it was at 6^h 15^m among the Hurons, it is clear that the Hurons lie 3^h 46^m west of the Atlantic meridian, and have a longitude of 303° 30'. Whether that is true, time will tell.

ECLIPSIS LVNÆ XXXIX. Æui mei 59.

Anno 1638. die 21. Decembris. Mane.

Lunar Eclipse XXXIX. The 59th of my lifetime. 1638 December 21, morning.

AT BRUSSELS [BRVXELLÆ], van Langren [Langerenus] obtained the beginning when 96° 33' was culminating — that is, at 10^h 29^m 8^s after midnight. He had the immersion when 111° 1' was culminating, namely at 1^h 26^m 49^s; the emersion when 135° 38' was culminating, which is 3^h 5^m 0^s. The end was not visible because of clouds. For him, therefore, the stay [Mora] was 1^h 38^m 10^s, and the middle accordingly at 2^h 16^m at the latest.

AT LEIDEN [LVGDVNI Batavorum], Golius assigns the immersion to 1^h 31^m, from the altitude of Aldebaran [Aldebaræ]. The emersion is inferred at 3^h 4^m 40^s, from the altitude of the bright star in the foot of Gemini [lucidi pedis Geminorum]. Six digits had been restored at 3^h 34^m 40^s, from the altitude of Arcturus; according to these, the end must have fallen at 4^h 4^m 30^s. The stay will have been 1^h 33^m 40^s; the middle, a little less than 2^h 18^m.

AT HERK [HERCII], I had the pure beginning [merum Initium] at 0^h 34^m, exactly enough. The immersion was noted at 1^h 32^m at the latest. The Moon emerged at 3^h 10^m, not a whit less; and 3^m later, with the Heart of Hydra [corde

Hydri] culminating, more than half a digit was already shining. The end was at 8^m [hor:8']²⁹, most plainly [planiffi-].

The penumbra, however, was conspicuous [Penumbra verò infignis] and lasted right up to 4^h 40^m, visible even after the cloud. The whole duration, therefore, was 3^h 34^m; each struggle [Lucta vtraque] 0^h 58^m; the stay [Mora] 1^h 38^m; the middle 2^h 21^m. Everything is the same as van Langren's [cum Langereno], and very close indeed to Golius's [cum Golio fanè quàm ex propinquo].

AT DIGNE [DINIÆ], Gassendi [Gaffendus] gives the beginning at 0^h 36^m and half a digit at 0^h 38^m; the immersion at 1^h 37^m; the emersion at 3^h 13^m; and finally the end at 4^h 14^m. For him, then, the whole duration would be 3^h 36^m; each struggle 1^h 1^m; the stay 1^h 36^m; and finally the middle at 2^h 25^m. Here there is a small difference from me, of 4 minutes, which is to be put down to the fading-out [intermorio].

AT FRANEKER [FRANICARÆ], Johannes Phocylides Holwarda [Ioannes Phocylides Holwarda] obtained the beginning at 0^h 33^m 30^s; six digits, which he fixed at 13.5' [horâ 13.5']³⁰; the immersion at 1^h 37^m; the emersion at 3^h 12^m; another six digits [Digitos sex alteros] at 3^h 44^m. The end was not visible because of clouds; but let it be granted that it fell at 4^h 14^m, by analogy. The whole duration, then, will have been 3^h 40^m; each struggle 1^h 3^m; the stay 1^h 35^m; and finally the middle at 2^h 24^m 30^s.

These figures, too, come out very nearly equal to Gassendi's [cum Gaffendo paria proximè faciunt]; but his beginning ran ahead of mine by a very little [me tantillo], and of Gassendi's by a little more [Gaffendum plusculo]. The first six digits agree with mine quite exactly [fatis partiliter]: for if at Herk [Hercij] they fell at 1^h 3^m, at Franeker they should have been completed at about 1^h 4^m. This agreement is quite remarkable, as is that of the emersion, which differs from my observation by barely a minute — and that surprises me.

My Atlantic calculation presents all the moments, van Langren's and my own, MORE ACCURATELY THAN CAN BE SAID [SVPRA QVAM DICI POTEST ACCVRATE].

ECLIPSIS LVNÆ XL. Æui mei 60.

Anno 1641. die 18. Octobris. Vespere.

Lunar Eclipse XL. The 60th of my lifetime. 1641 October 18, evening.

AT BRUSSELS [BRVXELLÆ], van Langren [Langerenus] had 4 digits 15' obscured at 6^h 47^m; 5 digits, therefore, were reached [tenuerunt] at about 6^h 56^m. Again, he had 5 digits 37' at 7^h 42^m; therefore 5 digits had been restored

²⁹so printed; no hour figure stands before the minutes

³⁰so printed; as it stands the figure does not fall between the beginning and the immersion that flank it

[relati fuerant] at 7^h 51^m, most plainly. For him, therefore, the middle was at 7^h 24^m exactly. The greatest defect observed was of 6 digits 47'; and at

7^h 30½^m he already had 6 digits 38', quite precisely.

AT LOUVAIN [LOVANII], Erycius Puteanus, having carefully compared everything, determined a doubtful beginning [Initium dubium] at 5^h 59^m and the extreme end [Finem extremum] at 8^h 53^m, so that the middle there fell at 7^h 26^m. This agrees excellently with the Brussels observation; but the false colouring of the penumbra [Penumbrae fucus] on either side drew the time out somewhat.

AT HERK [HERCII], we obtained the beginning at 6^h 8^m exactly; for at 6^h 12^m, too, half a digit was gone [aberat semidigitus], and at 6^h 15^m a digit. At 7^h 29^m the arc through the centres was already pointing toward the breast of Cassiopeia [in pectus Cassiopeiae], from which the middle was evident. At 8^h 42^m a digit was lacking; the same at 8^h 43^m, more precisely. At 8^h 45^m, something more than half a digit. The end was detected plainly at 8^h 50^m. Altogether, then, from this end and beginning as well, the middle is gathered to have been completed at 7^h 29^m, which agrees marvellously [ad miraculum] with the Brussels and Louvain observations. For me the digits were more than 6 digits 45' [suprà 6. 45'] — exactly as many as van Langren determined.

My Atlantic calculation represents all of this AS ACCURATELY AS ANY MORTAL CAN EXPECT [tam accuratè QVAM AB MORTALI EXPECTARI POTEST].

ECLIPSIS LVNÆ XLI. Æui mei 61.

Anno 1642. die 15. Aprilis. Mane.

Lunar Eclipse XLI. The 61st of my lifetime. 1642 April 15, morning.

AT LOUVAIN [LOVANII], Gerardus Gutiscouius [Gerard van Gutschoven], Doctor of Medicine and Professor of Mathematics [Doctor Medicus ac Mathefeos Profeffor], together with Guilielmus Regius [Guilielmo Regio] [?], his father-in-law, likewise a highly skilled mathematician, determined the beginning of the eclipse [Initium deliquij] accurately at the very instant [ipfiffimo punctiftitio] of midnight, the Moon having already passed the meridian by about one degree, with the Nadir culminating. 3 digits were lacking at 0^h 15^m. In the same town, in the Castle [in Arce], Puteanus noticed that the shadow had barely passed the meridian at the beginning of the eclipse. Clouds denied them [inuiderunt] the emersion.

AT HERK [HERCII], everything was carefully prepared — a telescope, a sundial [Scioterico], two water-clocks [Clepsydris duabus], and an adjusted striking clock [Horifonio composito] — and several young men of sharp sight and good ability were brought in, among them the brothers Ioannes and Philippus Vandelarius [Ioanne & Philippo Vandelariis] [?], of great promise,

sons of an excellent man. With everyone attending carefully to each detail, the observation proceeded as follows.

By the striking clock [Hori-fonio.]	Celestial time [Horâ cælesti.]	Phases of the Moon observed, and culminations of stars [Phases Lunæ obseruatæ & culminationes stellarum.]
12 ^h 0 ^m	11 ^h 55 ^m	<i>The Moon was grazing the meridian with its western limb.</i>
12 ^h 5 ^m	12 ^h 0 ^m	<i>The Nadir on the meridian; therefore midnight.</i>
12 ^h 8 ^m	12 ^h 3 ^m	THE BEGINNING OF THE ECLIPSE [INITIVM DELIQVII], evident.
12 ^h 15 ^m	12 ^h 9 ^m	A sixth of the circumference [Sextans Peripheriæ]; one digit, reddish.
12 ^h 30 ^m	12 ^h 23 ^m	Four digits, strikingly red.
12 ^h 45 ^m	12 ^h 37 ^m	7½ digits; more than a semicircle, faint [plus femicirculo languido].
1 ^h 0 ^m	12 ^h 51 ^m	10 digits, no fewer; already dark.
1 ^h 7½ ^m	12 ^h 58 ^m	<i>Culminating: the Southern Scale [Lanx Australis]. Only 10½ digits.</i>
1 ^h 12 ^m	13 ^h 2 ^m	It was ceasing to cast a shadow, although a digit that was in reality immersed was still shining.
1 ^h 15 ^m	1 ^h 5 ^m	A faint limb of half a digit was still seen.
1 ^h 30 ^m	1 ^h 19 ^m	It was now immersed, and had completely disappeared.
2 ^h 0 ^m	1 ^h 47 ^m	<i>The Crown [Corona] was culminating, the Moon being quite extinguished.</i>
2 ^h 45 ^m	2 ^h 29 ^m	<i>The Hand of Ophiuchus [Manus Ophiuchi] had passed the meridian by 1° 15'.</i>
3 ^h 0 ^m	2 ^h 43 ^m	IT WAS NOW EMERGING [IAM EMERGEBAT], and shedding light.
3 ^h 15 ^m	2 ^h 57 ^m	Three digits were shining, at the least.
3 ^h 30 ^m	3 ^h 31 ^m	Six digits, quite precisely.
3 ^h 45 ^m	3 ^h 25 ^m	Nine digits. <i>Culminating: the Head of Hercules [Caput Herculis].</i>
4 ^h 0 ^m	3 ^h 39 ^m	Something quite small was still lacking.
4 ^h 2 ^m	3 ^h 41 ^m	THE END [FINIS], evident by everyone's vote.
4 ^h 6 ^m	3 ^h 45 ^m	<i>The Head of Ophiuchus [Caput Ophiuchi] culminated.</i>

The whole duration was 3^h 38^m — as long as it was for Gassendi [Gaffendo] too, who at Paris [Parifiis] had some clouds, and later times, through the fault either of the instrument or of his servant. The first struggle [Lucta prior] lasted one hour for Gassendi, as it did for van Langren [Langereno] as well; for me it lasted a spurious 1^h 16^m [horam 1. 16' spuriam]. The second lasted only 59 minutes. As for those Louvain observations [Louanienfes illas] and the one at Herk [Hercanam], they are certain and beyond doubt to me; and the middle was at 1^h 52^m. For certainly at 2^h 10^m by the striking clock — that is, at 1^h 57^m celestial time — the eastern limb of the Moon, sought with difficulty and found only with trouble, was already somewhat more evident than the rest of the Moon's body, which was entirely extinguished [planè extinctò]. So the middle had in fact already passed.

My Atlantic calculation for Herk [Hercij] gives the beginning at 0^h 3^m, the immersion at 1^h 2^m, the middle at 1^h 52^m, the emersion at 2^h 42^m, and the end at 1^h 41^m³¹ — A MOST EXACT CALCULATION [CALCVLO EXACTISSIMO].

ECLIPSIS LVNÆ XLII. Æui mei 62.

Anno 1642. die 8. Octobris, Mane.

Lunar Eclipse XLII. The 62nd of my lifetime. 1642 October 8, morning.

AT LLEIDA [ILERDÆ], on the river Ebro [ad Iberum flu.], Antonius Garretus [?], who was at one time Gassendi's amanuensis, observed the beginning at 2^h 9½^m; one and a half digits [Digitum vnum cum femiffe] at 2^h 17^m; two digits at 2^h 19½^m; two digits and more at 2^h 21^m; seven digits at 2^h 47^m; 10½ digits at 3^h 3^m; eleven digits or more at 3^h 11^m, which was in fact the total immersion — but a spurious light [lumen spurium] lasted until 3^h 17^m. The emersion took place when the Moon was still 11° 0' high [alta gradus 11.0'], that is, at 4^h 50½^m at the very latest [horâ planè 4.50½ ad fummum].

My Atlantic calculation yields those first phases, and the emersion as well, PRECISELY, TO A MARVEL [AD MIRACVLVM PRÆCISE].

ECLIPSIS LVNÆ XLIII. Æui mei 63.

Anno 1643. die 27. Septembris, Vespere.

Lunar Eclipse XLIII. The 63rd of my lifetime. 1643 September 27, evening.

AT ANTWERP [ANTVERPIÆ], in the house of the noble Iacobus Edelherius [Jacob Edelheer], syndic of the city — where there is every kind of instrument, and among them a very large mural sundial [Sciotericum ... murale, maximum] — we attended the observation: the most esteemed Iacobus Eyckius [?], High Treasurer of the City [Supremus Vrbis Thefaurarius]; the most distinguished Caspar Gevaerts [CASPERIVS GEVARTIVS], chief secretary of the city [vrbs Archigrammateus] and also my most delightful host; then van Gutschoven [GVTISCOVIVS], here truly attentive if ever he was; likewise Dudingius [DVDINGIVS] [?], and that Anna Romeria [ANNA ... ROMERIA] [?], the Theano of our age, with many others.

By the striking clock 6^h 30^m; celestial time 6^h 36^m.

The Moon, having struggled free of the clouds, let itself be seen, eclipsed by at least half of itself [falter dimidiatâ fui parte deficiens]. The western horn was raised and the eastern lowered; and it [illa] appeared not yet to be parallel to the Moon's path, and much less to the ecliptic. From this it was established that the middle had not yet come. We could not draw the arc through the centres [Arcum per Centra], because of the clouds, which covered the Moon again.

³¹so printed; the end stands before the emersion at 2^h 42^m

By the striking clock 6^h 45^m; celestial time 6^h 51^m.

The Moon was still hidden behind a cloud. It emerged from it a little later, about 3 minutes, that is, at 6^h 54^m or 55^m celestial time at most; and the arc through the centres then passed through the head of Andromeda. So the middle had already been passed about 2 minutes before, and [&] — in any case from 6^h 52^m celestial time [omnino ex horâ 6.52' cælesti]. The horns, too, had by then become parallel to the Moon's path, which confirmed the same thing.

By the striking clock 7^h 0^m; celestial time 7^h 6^m.

Again it was eclipsed by half the diameter, and the arc through the centres was pointing toward the tip of the wing of Pegasus [in extremam alæ Pegafî]. This, likewise, shows clearly enough that the middle had been passed before 6^h 53^m. If the defect had been equal to the earlier one, the middle would have been at 6^h 51^m.

By the striking clock 7^h 15^m; celestial time 7^h 21^m.

There were still 5 digits and a quarter eclipsed, or a very little more. The arc through the centres was now grazing the shoulder of Pegasus [armum Pegafî]; from this, again, it appeared quite precisely that the middle had been at about 6^h 52^m [horâ 6. 52' admodum]. The horns were now parallel to the horizon, in the judgement of van Gutschoven [Gutiscouio]. The Eagle [Aquila] had culminated 4 minutes before; from this it was in fact established that the celestial time of 7^h 21^m had been correctly determined.

By the striking clock 7^h 30^m; celestial time 7^h 36^m.

4 digits were still eclipsed, fully a third of the circle, as van Gutschoven declared and everyone agreed [assentientiquisque omnibus].

By the striking clock 7^h 45^m; celestial time 7^h 51^m.

The horn of Capricorn [Cornu Capricorni] had now passed the meridian [metidianum] by a degree and a half, which confirmed the true time. Two whole digits were still lacking, quite precisely. Van Gutschoven declared it a fifth part of the circle [quinctam partem Circuli]. The shadow, with its uneven fringes, seemed plucked away bit by bit [carptim defloccata]; and immediately afterwards the bright star of Cygnus [clara Cygni] culminated, at 7^h 52½^m.

By the striking clock 7^h 57^m; celestial time 8^h 3^m.

In everyone's judgement something was still lacking, about half a digit. While van Gutschoven and the others were watching closely, with the naked eye as well as with telescopes, for the lunar limb to become whole, the warning chime [prætinnio] of the striking clock began, as it was about to strike. Van Gutschoven declared that he now at last saw the limb whole, and hurried over to the sundial [Sciotericum]. There, as the first stroke of eight was sounding, he found the Moon's shadow marking the very eighth hour, most precisely — not so much as a hair short. So the pure and true end was found by all of us.

By the striking clock 8^h 0^m; celestial time 8^h 6^m at most.

And since the limb was cleared [depuratus] while the warning chime was still sounding, we can assert that the moment of the true end was at 8^h 5^m 30^s.

IN WONDERFUL AND ASTONISHING AGREEMENT WITH MY ATLANTIC TABLES [CONSENSV CVM TABVLIS MEIS ATLANTICIS MIRABILI AC STVPENDO].

And here, with my climacteric year, let a climacteric eclipse close the line of march [claudat agmen]: which, for confirming those two paradoxes, either is enough, or will be nothing. And let this be, from now on, of surer calculations THE BEGINNING [PRINCIPIVM]; of errors, at last, THE END [F I N I S.]

CENSURA.

Censorship.

The Eclipses of the most distinguished Master Godefridus Wendelinus [Govaert Wendelen], since they contain nothing contrary to faith or good morals, may safely be published. Done at Brussels, this 1643 December 1. Henricus Calenus [HENRICVS CALENVS], Licentiate in Sacred Theology, Archdeacon of Mechelen, Censor of Books.

ERRATA PRÆCIPVA.

The Principal Errata.³²

Page, line [Pag. lin.]	Correction as printed	English
2. 7.	scrupulofiffima.	read <i>scrupulosissima</i> ("most scrupulous")
7. II.	min. 6.	read "6 minutes" [min. 6.]
Ibid. 16.	centrum.	same page, line 16: read <i>centrum</i> ("centre")
Ibid. 22	5.54' & 6.6'. vbi ferê quadrans d.	same page, line 22: read 5.54' and 6.6' [5.54' & 6.6'], where there is nearly a quarter of a digit ³³
20.14.	Quid ergo.	read <i>Quid ergo</i> ("What then?")
24.29.	Si homini omni,	read <i>Si homini omni</i> ("If to every man")
35. Vltim.	Plenilunium.	page 35, last line: read <i>Plenilunium</i> ("full moon")
42.19.	Progymnafmatis.	read <i>Progymnasmatis</i> (of the <i>Progymnasmata</i>)
48. I.	TYCHONICA.	read <i>TYCHONICA</i> ("Tyconic")
49.	Eclips Solis præponenda fuerat antecedenti Lunari.	page 49: the solar eclipse should have been placed before the preceding lunar one
51.2.	Augusti Iuliani.	read <i>Augusti Iuliani</i> ("of Julian August")
56.57.	Arcturi.	read <i>Arcturi</i> ("of Arcturus")
58.20.	colore.	read <i>colore</i> ("in colour")

³²Each entry gives the page and line of the printed book, followed by the corrected reading.

The corrected readings are Latin words of the text and are kept in Latin, with a gloss.

³³*d.* expanded as *digiti*, "of a digit", from the locus this entry corrects

Page, line [Pag. lin.]	Correction as printed	English
67.	aliquoties repondendum [recte: reponendum] Automatum.	page 67: <i>Automatum</i> ("the automaton", i.e. the clock) is to be restored in several places
74.26.	Legitima.	read <i>Legitima</i> ("legitimate")
75.15.	Nancisci.	read <i>Nancisci</i> ("to obtain")
77.	Eclipsis Solis irrepsit me absente ex Schedis. Ibid. existitiffe.	page 77: the solar eclipse crept in from my loose notes while I was away. Same page: read <i>existitisse</i> ("to have existed")
81.	Eclipsis Solis item præter mentem meam infulta.	page 81: the solar eclipse was likewise inserted against my intention
84.6.	divinatione incertâ, correctione dubiâ. Omnino Medium erit.	read <i>divinatione incerta, correctione dubia. Omnino Medium erit</i> ("the conjecture being uncertain, the correction doubtful. The middle will certainly be ..." — the sentence continues with the time printed on p. 84)

The kind reader will forgive me the rest, since I was working in haste and was from time to time away. [Reliqua beneuolus lector festinanti mihi & fubinde absenti condonabit.]

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