Nechmad ve-Na'im

נחמד ונעים

(c. 1613)

by David Gans (דוד בן שלמה גנז), 1541–1613

Translation by Scott Weisman

Ars Astronomica

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Translator Version 2

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

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

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

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A note on the work

A Hebrew textbook of astronomy that presents the Ptolemaic model of the heavens for a Hebrew-reading audience, weaving the cutting-edge European science of its day together with the medieval Jewish cosmological tradition — its author having personally visited the Danish astronomer Tycho Brahe. Organized into twelve sections and 305 numbered paragraphs, and closing with a Latin preface by the Leipzig Hebraist Johann Christian Hebenstreit. First and only printed at Jessnitz in 1743, more than a century after it was written, it stands as a remarkable monument to Jewish engagement with the science of the age.

A note on the translation process

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

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

Acknowledgements

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[Front matter leaf — modern National Library of Israel scanning notice, not part of the 1743 edition. Printed in modern Hebrew type beside the NLI logo: "הספרייה הלאומית" / "THE NATIONAL LIBRARY OF ISRAEL" (with Arabic "المكتبة الوطنية الإسرائيلية"), and below: "ספר זה נסרק על ידי הספרייה הלאומית" — "This book was scanned by the National Library."]

[Flyleaf — blank leaf bearing modern library markings only, no printed text of the work. Handwritten pencil shelf-marks: "R8° 35 V 1770 / copy 2"; "S.R."; "52 ע"; a crossed-out Hebrew note (largely illegible); and a faint rectangular library ownership stamp in Hebrew (National Library, Jerusalem [?]).]

ספר נחמד ונעים — Sefer Nechmad ve-Na'im

Sefer

Nechmad ve-Na'im ["Pleasant and Delightful"]

From the Perfect in Knowledge [*mitmim de'im* — a play on Iyov 37:16] — a fair and beautiful composition, in a clear and easy tongue, upon the whole of the science of astronomy, the sanctification of the New Moon, and the measuring of the stars, together with the shapes of their observational instruments; and the knowledge of all the climes [*aklimim*], to understand the map of the world called *Landkarte* [German: "map"]; and other wondrous matters that are heard and seen from within it.

Which was composed and established by the perfect sage in the lofty degrees of geometry, and in the science of measurement, of astronomy, and of the measuring of the stars and figures — the divine philosopher — namely, the Rabbi, the [*ha-ma...h"n* — title abbreviation garbled, ?] Gaon R. **David Gans** [דוד גנז], author of *Sefer Tzemach David*, *Sefer Ma'or ha-Katan*, and *Sefer ha-Prozdor*, of blessed and saintly memory — [a work] which was found in manuscript, stored away and hidden since the year 373 of the sixth millennium [5373 = ג"שע AM = 1613 CE], until this day unseen by any beholder's eye.

Brought to the press by the Rabbi, the Gaon, our teacher R. **Yoel son of** our teacher R. **Yekutiel**, of blessed memory, Av Beit Din of the holy community of Austerlitz [אוסטרליץ], a native of the holy community of Great Glogau [גלוגא רבתי / Glogau], to bring merit to the many — and the merit of the many depends upon him.

And also — remember him for good [*zochreihu tov*] — to the good: the exalted chief, the officer, the honored R. **Ber Hess** [בער העס] of the holy community of

Halberstadt [הלברשטט], who was moved [?] with him to pour out his purse of money; from the drawing [?] of his hand, full as a ladder [?], for the expenses of the printing. May the LORD reward his deed and may his wage be complete [Rut 2:12]; may [it be] a completed [work, ?]; and may he merit an everlasting edifice.

Printed here in the holy community of **Jessnitz** [יעסניץ], at the press [*bi-veit defus*] of R. Israel son of Avraham, of blessed memory.

By the count [chronogram, transliterated — reading uncertain]: לפרט טאו קרנס טיינס וראומי ברא א"ה [?]

התנצלות דברי הרב המביא לדפוס — The Apologia: Words of the Rabbi Who Brings [the Work] to Press

Come, behold the works of the LORD, who has made desolations in the earth [Tehillim 46:9] — that we may know the righteousness of the LORD; who has set His dominion in the earth [cf. Iyov 38:33, ?]; who stretches out the north over the void [Iyov 26:7] and upon the foundations of emptiness; and from what have I [the means] that He brought it into being — and who teaches as He does? [Iyov 36:22] — [who ordains] the [channels? *m'tzanrei*, ?] of the constellations [*Mazzaroth*] upon the observer's horizon: their courses and their deviations, their risings and their [settings, ?]. He is the One who created us — the Necessary Existent, the Cause of causes — without weariness and without fatigue.

To bring to completion [?] — for the One awesome in praises [Shemos 15:11], my silence is fitting; with stammering lips [cf. Yeshayahu 28:11] I have laid my hand [upon my mouth]; yet fair is the discourse of a servant like me, acceptable to all my multitude — those whose little finger is thicker than my loins [I Melachim 12:10] — who have stirred me and brought me hither to ascend among the heavenly bodies, to bring down for them the bread of the mighty [Tehillim 78:25], to declare the greatness of the Fashioner of Creation, who has done wondrously — [who stripped, ?] my skin from me; the fetters [*azikkim*] of the Almighty, to fulfill my desire and to satisfy my thirst — parched and thirsty [cf. Yeshayahu 5:13].

This while, day by day [?]: "I, Wisdom, dwell with prudence" [Mishlei 8:12] — and from me she is bared — to know the dwelling of light [Iyov 38:19] [among] the stars in their courses; the joining of [*charp...sahar*, ?] in their points, and the

generations of the light in their distances; to know how to fly [?] — as befits us — the words of Moshe our teacher, who built and who stretched out, and inclined lovingkindness over us; in the laws [*bi-dinei*, ?] of the sanctification of the New Moon, full and heaped up — matters which the earlier ones did not [fully] fathom, [things] new and also old [cf. Shir ha-Shirim 7:14]. And I turned to every side to understand, in the books of instruction, saying: Where is the seer? — "and there is none among us who knows how long" [Tehillim 74:9].

And from the time the LORD made the settled lands quake, and states were confounded by armies [*geyasot*], kings contending one with another — we made ourselves an exile's baggage [Yechezkel 12:3-4], driven away, wholly consumed — from my dwelling-place, to the land of my birth, to seek out for me a place of rest [cf. Bamidbar 10:33], and to the city of Bre[?]kl [ברעכל, city-name garbled, ?] I came. I [built, ?] — like a bird wandering from its nest [Mishlei 27:8] I strayed, and I lodged in the clefts of the rock [cf. Yeshayahu 2:21], until the LORD should look down and see [Eichah 3:50] the worm upon me [?]. And the LORD brought about before me [those] "who dwell at Shevet, the Tachkemonite" [II Shmuel 23:8] — they taught me and made me wise, and their wisdom [*charh...*, ?] raised me up: the way of a ladder set upon the earth, its top [reaching] to the windows of heaven [Bereishis 28:12], and my words combed out [as] "matters just as they are written" [Aramaic: *divrei ki-khtavan*, "words as inscribed"], which came into my hand as one who hears the sense of those who expound.

The book *Nechmad ve-Na'im*, which the great investigator composed upon the science of astronomy, with all the figures pertaining to this science, and the clarification of all the sayings of the sages — whether of the sages of Israel or of the words of the sages of the nations of the world who have made innovations in these matters — all of it explained, and he has refined [it] finely, in a clear tongue, brilliant and lucid, and so forth. Whoever wishes to approach the inner court will find a response, and rest, from the God of old, the dwelling-place [Devarim 33:27] — namely, the Rabbi, the author, the master of *Tzemach David* — like a necklace of ornaments, like bracelets upon [his] hands. For these hundred and thirty years his words lay concealed, no eye beholding them, in the capital city of **Prague** [פראג], since the day his light was hidden away.

And I gave a ruling for the past — and it is a time to speak [cf. Koheles 3:7] — in honor of the author: that I have merited to copy out his words, in his chapters and his orders, and to raise them upon the altar of the press, to magnify Torah and make it glorious [Yeshayahu 42:21]; so that the reader may run through it [Chavakuk 2:2], in the clarity of its tongue, sweeter than honey to his palate and

his throat [cf. Shir ha-Shirim 5:16], in the science of astronomy — and to show a welcoming face to students, the seekers of precious things.

For not so is the way of the ancient inquirers and researchers — the way of the ancient inquirers, [who] hung upon them weapons and shields [cf. Shir ha-Shirim 4:4], the way of riddles and conjectures. And in the lowliness of our generation, in the smallness of our heart and the shortness of our understanding, we have gone very low, we have reached the dust [?] — and it is far from me; we have not [attained, *lo ka-eshnu*, ?] as far as the center; and at the opening of the innovation [*ha-mechudash*, ?] the gates of knowledge and reason [*hozeh*] were shut, from hasty reasoning [Aramaic: *me-ama peziza*, "of a hasty people/taste," ?], and their [obscurities, ?] were twisted and perverse. But now the windows of heaven have been opened [Bereishis 7:11]: flat surfaces and concavities [*ha-sh'tichiyot ve-ke'aruriyot*] have been [stretched out, ?], guarded in every part and set in order [II Shmuel 23:5], showing the way to the perplexed [an allusion to the *Guide for the Perplexed* / *Moreh Nevuchim*], with just and right words [Mishlei 8:9], clear and restful. And whoever wishes to take up the [good] Name...

The Apologia (continued) — *Hitnatzelut*

May the Name ready [me] in haste to draw near to the work, and from the LORD may he bear a blessing (Tehillim 24:5); "Who created these?" (Yeshayahu 40:26) — upon a paved road, perfect in beauty. And all of them shall know the LORD, from the least of them to the greatest (Yirmiyahu 31:34), as the waters cover the sea (Yeshayahu 11:9). He will find the near road, and in a short while perceive how sweet it is.

And these are the last words of David (2 Shmuel 23:1) — more desirable than gold and darics [אדרכמונים], and, above all precious treasures, stored away (cf. Tehillim 19:11); sweeter than the flowing honeycomb (cf. Tehillim 19:11), pleasant plantings (Yeshayahu 17:10), and strong as the oaks (cf. Amos 2:9); mighty in the commandments and turned toward every side. From it there issues the learning fit for childhood [Aramaic: גרסא דינקותא, *girsa de-yankuta*]; "the small and the great are there" (Iyov 3:19) — to establish the words of the Maimonidean [the laws of *Kiddush ha-Chodesh* of the Rambam] with but a little study, so that "he who tends a fig tree shall eat its fruit" (Mishlei 27:18).

And to the holy city we shall go up in song, to sanctify the new moon in its [proper] time [כזמנה [?]]; and by the mean and true motion [מהלך אמצעי ואמיתי], "He withdraws not His eye from the righteous" (Iyov 36:7). "The righteous walk in them" (Hoshea 14:10), and each man turns to his own way (Yeshayahu 53:6) — a

road [made strong] and southward, and they shall spread abroad, the way eastward [קדים] and northward (cf. Bereishis 28:14).

The author's plea and a talmudic-astronomical excursus

[The rhymed apologia now passes into a first-person humility passage and then into a dense scholarly note. The lower two-thirds of p. 5 are small, faded type with heavy show-through; much of the technical argument could not be read with confidence and is flagged. The page]

And now I have made light [of my burden] [?], in the manner of my petition [?], in the height of my brokenness and lowliness. Lowly am I, as one who knows the baseness of my worth; I have not presumed [?], and I have strayed [?]; I have not fulfilled [?] the ways of my teachers, my parents, and my masters — [rather] to blacken myself like the kettles [Aramaic: כקדרי, an idiom for toiling] in the hall [בטרקלין], that my words might shine like light, with the help of my God, my Rock — to settle the language of the Gemara [?].

[There follows a scholarly excursus reconciling the dispute in the first chapter of Pesachim (פ"ק דפסחים [Pesachim 94b]) — the disagreement over the sun's path at night, and how far the heavens are from the earth and how far from east to west [מן השמים לארץ … רחוק מן מזרח למערב]. The discussion turns on the center of the spheres of the firmament [מרכז גלגלי רקיע [?]], the mean and true motion [מהלך אמצעי ואמיתי], sunset [שקיעת החמה], the seasons [תקופת], and the four directions. It cites Rashi [רש"י], the Maharsha [מהרש"א], *Ein Yaakov* [עין יעקב], and Mizrachi [כמזרחי ז"ל — R. Eliyahu Mizrachi]. The body of the derivation — including several bracketed numerals and the linking argument — is largely illegible on this scan: [Illegible: dense technical passage, roughly a dozen lines].] [?]

[Closing.] … as R. Shmuel [ר' שמואל [?]] wrote — from this you will understand, in his introduction [?] — [that] where a word is lacking, or superfluous, or a term [is dropped], I took pains to correct the figures [הציורים] of every error. Were it not for this I would not [?] have lifted my hand to alter [?] a thing; but the words of the author himself [I have kept] as [in] the book [כמו … בפתיחת ספרי זה — "in the opening of this my book," his own words]. And I saw fit to set down first [?] … Israel [?] by demonstrative proofs. Their words are as desirable and pure [?] as [the work's] plan [כתכונה], and upon them [these matters] verses of Scripture have been made to rest [?]. For this reason I made a gate and an opening [שער ופתח] by which to enter the hall [בטרקלין], and whoever reads his [the author's] words will find rest for his soul [ימצא מרגוע לנפשו]. [Judge me not for] any wrong [?] … Full and complete is the preparation [?].

[Signed:] … [dated] the festival of Purim [יו"ט דפורים [?]], [5]503 according to the abbreviated era [תק"ג לפ"ק — Purim 5503 AM = 1743 CE; 5503 − 3760 = 1743].

Index / Keys to the Paragraphs — *Miftechot li-Simanim* (pp. 6–8)

Siman	Topic
1	Beneath the sphere of the Moon come to be the four elements, one above another; and an explanation of the first element.
2	The second element, water; that the earth combines with the water to form together a single [terraqueous] globe.
3	That one must not inquire into the reason and cause why the globe of the earth hangs in the midst of the air "upon nothing" (בלימה, Iyov 26:7).
4	The third element, the air, which divides into three parts.
5	That the air divides into ten different aspects; and the distinction between *nefesh*, *ruach*, and *neshamah*.
6	The fourth element, fire; and the property by which the elements interpenetrate one another [?].
7	That the later authorities deny the element of fire above entirely.
8	The number of the planets, their names, their order, and their periods of revolution.
9	That each planet is set in its own firmament; and why they are called "wandering stars" and "wandering [perplexed] stars" (כוכבי לכת ונבוכים).
10	On the eighth sphere, called the sphere of the [fixed] stars, or the sphere of the zodiac, and its motion.
11	That all seven planets, together with the stars of the zodiac sphere, are revolved by their spheres from west to east.
12	On the ninth sphere, called the diurnal sphere, whose motion is the reverse of that of the eight spheres mentioned.
13	How one body may be conceived to have two opposing motions.
14	How one body may be conceived to revolve eight bodies, one

Siman	Topic
	within another.
15	A fine resolution of the two perplexities mentioned.
16	A further return to the two perplexities mentioned.
17	Why the ninth sphere is called the diurnal sphere, and that it has but one motion.
18	Differing opinions concerning the existence of the ninth sphere.
19	Some explanation of the adjacent figures.
20	That the shells of the spheres are like the layers of an onion, with no void between them, and are transparent as sapphire.
21	The central axis [מברית] and pole of the sphere, and the two pivots and poles of the universe.
22	That the northern pivot and the southern, mentioned above, are alone the pivots of the ninth sphere.
23	That even those who deny the ninth sphere may fittingly speak of a "diurnal sphere" or an "uppermost motion."
24	That every star makes, each day, one circle about one of the pivots.
25	Whether the star is fixed and the sphere turns, or the sphere is fixed and the star turns.
26	To find, in the eighth firmament, the point opposite the northern pivot of the ninth sphere.
27	The figure of the Great Bear and most of the Little [Bear]; and that the said pivot is not [the true one] but resembles / lies opposite the true pivot.
28	The force of the proofs that the heavens are spherical, and that no figure is like the spherical figure.
29	That the circular figure holds [contains] more than all [other] figures.
30	That the zodiac sphere is divided into 360 parts along the length of the world, and likewise along its breadth.
31	The nature of the sphere [?] … [as regards] the eighth sphere, its diameter and its poles.
32–33	The number of the great circles of the sphere, and the

Siman	Topic
	depiction of its form. *[Printed as a single entry for two siman-numbers —]*
34	Explanation of the first circle, called the celestial equator (משוה היום).
35	The second circle, called [?] — or the horizon (אופק), or the circle of vision (עגול הראִיה), or the earth's circle (חוג הארץ).
36	The third circle, called the meridian (אופק חצי היום).
37	The fourth circle, called the ecliptic (עגול המזלות).
38	The fifth circle, called the circle of the four pivots, or the colure (מעמד הגלגל [?]).
39	The sixth circle, called the equinoctial colure (מעמד השוה).
40	The seventh circle, called the summer [solstitial] colure (עמידת הקיצית), or the circle of Cancer.
41	The eighth circle, called the winter [solstitial] colure (עמידת החורפית), or the circle of Capricorn.
42	The ninth circle, called the northern (Arctic) circle.
43	The tenth circle, called the southern (Antarctic) circle.
44	The distances of the three circles — the equator (קו היושר), Cancer, and the northern — one from another.
45	Constructing the meridian circle by another method; [and?] its usefulness [?].
46	To make upon the southern globe an arc [for measuring] the distance of the stars [?].
47	That the horizon-line, and likewise the meridian-line, are shared by two persons distant one from another.
48	That the farther a person is from the equator toward his north, so much greater is the elevation of the pole above his horizon.
49	That all the stars near the northern pole never set for us.
50	To find the mean line of the south by direct observation, [throughout] the seasons of the year [?].
51	Constructing an observational instrument called the "square instrument," in Latin *quadrant* (קוודרנט [Latin: *quadrans*]).
52	To find the altitude of the sun, and likewise of every other

Siman	Topic
	star — how high it is above the horizon.
53	To find the altitude of the northern pole above your horizon, and the place of its point in the firmament.
54	To find the moment and time of midnight throughout all the days of the year.
55	Proofs and evidence that the earth is spherical.
56	That many men have circumnavigated the entire globe and returned to the place from which they set out.
57	That the earth stands at the very center of the zodiac sphere, like a point at the center of a circle.
58	That the earth's globe, by reason of its smallness, has no magnitude perceptible to our sight against the vast breadth of the zodiac sphere.
59	That all the lines of the celestial circle above are conceptually inscribed upon the earth's globe below.
60	That the earth's globe too is divided into 360 degrees, in longitude and in latitude, and from what place this reckoning begins.
61	How the ancients knew that the longitude-measure of the dry land is [about] half the earth's circle — namely 180 degrees.
62	How many parasangs on the earth's globe correspond to one of the 360 parts of the sphere above.
63	The measure of the line encircling the earth's globe, and how many days and years a person needs to travel around the globe.
64	Refutation of the ancients' opinion that half the earth's globe is submerged in water.
65	Whether the earth stands upon the water, or the water upon the earth.
66	Refutation of the ancients who said that near the equator there is no habitation, from the great heat, and near the northern circle none [from the cold]; and an explanation of the seven climes (אקלימים).
67	The reason why the ancients divided the inhabited world

Siman	Topic
	into seven climes.
68	The form of the whole terraqueous globe, sea with dry land, all the [eight] parts, in general terms [?].
69	Explanation of the 32 tables (ל"ב הלוחות [?]), and clarification of some of their circles.
70	A drawing of the earth's globe as a cone [?], which is more like a curved sphere [?].
71	That the ancients divided the inhabited world into three parts: Asia (אסיא"ה), Africa (אפריקא), and Europe (אירופיא"ה).
72	That the sons of Noah — Shem, Ham, and Japheth — divided the three parts of the world among themselves.
73	On the discovery of a new world, called America (אמריק"י), in the year 5252 [5252 = ה' אלפים רנ"ב AM; 5252 − 3760 = 1492 CE].
74	That the fifth part of the earth's globe is also in the new world, and that part is called Peru (פיר"ו).
75	A note on the [region] of the said Peru, which is the fifth part of the globe [?].
76	Some say that the land of Peru is Ophir (אופיר), whither Solomon (peace be upon him) sent his ships (cf. 1 Melachim 9:28).
77	Explanation of the sixth part of the globe, called New Guinea (גביניא"ה [?]).
78	The seventh part of the globe is the northern world.
79	The eighth part of the globe is the southern world, larger than each of the other parts of the world.
80	Who told the explorers of the land [?] of the locations of the world and the boundaries of the seas.
81	How and whence the researchers know the latitude of countries, between north and south, and their breadth, between east and west.
82	To find the longitude of countries without observation of eclipses (לקויים).
83	To find the longitude of sea-islands without observation of

Siman	Topic
	eclipses, and without two [observers?] [?].
84	To know the longitude of countries by the times of the moon's revolutions, according to its proper and outer motions, together with the revolution of the diurnal sphere [?].
85	The bounds of the four directions of the world — where they begin and where they end.
86	That the ancients divided the horizon-circle into twelve directions.
87	That the later authorities divided the earth's circle, or the horizon, into thirty-two directions [compass points].
88	An alphabetically-ordered table [?] by which to know the locations of many inhabited places, and also some sea-islands — how much each is in longitude and in latitude.
89	A resolution concerning what our Sages said, that Jerusalem is the center of the world.
90	A resolution concerning their saying that the Land of Israel is higher than all lands.
91	The reason why the later authorities challenged what the earlier ones received concerning the beginning of the 360 degrees of the globe [?].
92	Explanation of the time-periods — five in general; and the duration of the year and the month are explained.
93	That there is no [fixed] month at all, and the moon has no year at all [?].
94	On the natural days, which run "from one time to the same time" (i.e., 24-hour periods).
95	On the hours of the day, and on what its foundations were sunk (cf. Iyov 38:6) [?].
96	Why they divided the measure of the parts of the natural day into 24 hours.
97	

Index of Paragraphs (מפתחות לסימנים) — continued

Source page 9 (folio ד[?] recto)

97. The reason for the seven days of the week.

98. A table for the rulership of each of the seven planets in every hour throughout all the days of the week.

99. On the duration of each of the wandering planets' [כוכבי נבוכה, *kokhvei nevukhah*] rulership — not only in the first hour of the day, but ruling a whole day.

100. On calculating the equal hours (*sha'ot yesharot*) of the natural equinoctial day, equal to one another.

101. On calculating the seasonal hours (*sha'ot me'uvvatot*), called *zemanim*, which are always twelve hours by day and twelve hours by night.

102. On what else the reckoning of the seasonal hours was founded upon.

103. That the reckoning of the intercalation (*ibbur*), the seasons (*tekufot*), and the conjunctions (*moladot*) was established according to the seasonal hours.

104. On the cause of night, and the earth's shadow.

105. The meaning of the word "day"; the difference between the artificial (working) day and the natural day, and from what moment it begins.

106. That the length of a natural day exceeds the time of one revolution of the daily sphere.

107. On the belts of the zodiacal constellations and their figures, and why they are called by their known names.

108. For what reason the astronomers assigned to the zodiac circle the aforementioned [star / name] [?].

109. That the ancients agreed, with reason and good sense, to place the sign of Aries at the head of the zodiac.

110. That the figures on the zodiacal sphere are reckoned in two ways.

111. That the figure-bearing constellations in the eighth sphere are not equal to one another in measure, neither in their length nor in their breadth.

112. That all the stars of the firmament are distributed among the twelve signs.

113. That they divided the zodiacal sphere, reckoned according to seven considerations.

114. The six signs to the left of the horizon are found [equal in their rising] to the east and [...] to the west only for those dwelling under the equator. [reading uncertain — several words garbled: "לא נמצא בהם ג'למזרח ועל'שה למערב" ?]

115. That each sign takes two hours in its rising over the horizon.

116. That six signs rise each day, and likewise at night, whether the day or the night be long or short.

117. Explanation of the ascensions (*mitz'adei*) of the signs; some signs rise slowly (at length) and some rise quickly.

118. Explanation that in four places the degrees of the zodiac change together with the degrees of the equator (right ascension).

119. The order of precedence and following, according to the order of the four quarters of the sphere.

120. A small table [showing] how many degrees and minutes, and also how many hours and minutes, [belong to] the rising of each sign, whether in the right [sphere] or the oblique.

121. The rules of precedence and following in the ascensions of the signs, for those dwelling under the oblique [horizon].

122. A table of the risings and settings of the signs for us, the inhabitants of the city of Prague.

123. That for some people every sign [reaches] the horizon each day, and [...] signs are seen by them, half above the horizon and half below it. [middle words garbled: "וב'א מ'לב מזלו' נראין" ?]

124. When the axis of the zodiac mentioned inclines above the heads of people dwelling under the northern circle, as above.

125. That we noted: three of the remaining signs are always above the horizon, three always below it, and three that rise and set inverted.

126. At [a certain place] four signs always remain above the horizon and four below it; and for some, six above their horizon and six below it, always.

127. The reckoning of the rising of the signs over the horizon; some of them have an evening rising and some a morning rising.

Source page 10 (folio ד[?] verso)

128. On the rising of the twelve signs in a year, and that there is nothing anomalous in it from the revolution of the zodiacal sphere.

129. That the rising of the aforementioned signs is not exact in every year, nor is it equal for all the inhabitants of the world (*cheled*).

130. On the time of the revolution of the zodiacal sphere. [line garbled in source: "מזמן ס :וכ גלגל המזלות" — reconstructed]

131. It informs that, after many years, all the host of heaven will change for us.

132. It defines [?] the sun's deviation from the equator — called in their language *declinatio* [דיק'לי נצייאנו'ס; Latin: *declinatio*, "declination"] — and the two circles that the sun makes twice [a year].

133. We shall explain and make known that most of the sun's regions (*galilei*) are shared with one another.

134. Explanation that the sun's regions are not complete circles.

135. We explain that the sun's shared regions are not [perfectly circular] in precise form, only at their beginning. [reading uncertain]

136. Explanation that the sun's aforementioned regions are not equal in nearness and farness to one another, and that the sphere [...]. [end of line garbled/cut at margin]

137. [Siman 137 — its description not legibly recovered from the source; only the siman number "קלז" is clearly visible.] [?]

138. Explanation that, for those dwelling under the equator, the length of the day and the length of the night are always equal.

139. Explanation that on the days of the two equinoxes, day and night are equal also for most of the other inhabitants of the world.

140. Explanation that the daytime of the Nisan season (the spring half-year) exceeds the daytime of the Tishrei season (the autumn half-year).

141. It informs that the natural [?] days are not equal in the measure of their length.

142. It makes known the cause of the lengthening and shortening of the days for us, the northern inhabitants, throughout all the days of the year. — Further (a siman connected to the above): that the length of the days of Teves is never equal to [...], and likewise their daytime is never equal to their nighttime. [appended note; several words garbled: "...לסי' הנ"ל שמרת ימי טבת אינ' שוי' לא'ד'... תמיר וכן יומו"]

143. Explanation that for some people the measure of the day will be [?] hours. [number of hours illegible]

144. It informs that in some countries the [longest] day is one month, or two months, or more, and likewise the night.

145. That in some places the day is four months, and likewise the night.

146. That for those dwelling under the north pole, the day is six months and likewise the night.

147. To investigate and know, by means of the globe-instrument, the lengths and shortnesses of the days for every day of the year, in every place and every time.

148. The differences found among the inhabitants of the world in the beginning of each day, and the moments of their midday, in general.

149. The rule of precedence and lateness for those dwelling under the equator (the right line).

150. Those who share the same latitude have equal day-length, all of them.

151. Places that share the same longitude have equal midday time, all of them — but not so the division of day and night, except on the days of the Nisan and Tishrei equinoxes.

152. Places that share neither longitude nor latitude — how many rules and laws they have relative to one another.

153. That there are some western countries where the sun rises for them before it rises for the eastern ones.

154. That the sages agreed to relate events according to the times of midday and midnight.

155. The precise reason for knowing the aforementioned differences.

156. On the variation of summer and winter, and that those under the equator have two summers and two winters.

157. That those dwelling toward the equator also have [seasonal] reversals and four general [divisions].

158. The nature of the summer and winter sun for those dwelling under the Tropic of Cancer (*iggul Sartan*) and beyond it.

Source page 11 (folio ה recto)

159. Why at midday it is [warmer]... in the west; why the west is warmer than the morning; and why it is colder in the winter season than in the summer season.

160. That the cause of day and night, of summer and winter, and of all the other seasons of the year — all of them likewise result from the two motions, the voluntary and the necessary.

161. From which place on earth each day begins to be called by its name.

162. One who circumnavigates the globe will sometimes lose one day of the week, and sometimes gain one day.

163. Explanation that in the sun, and likewise in the other planets, there are found changes and many differing matters.

164. The definition of the solar year, and how long its measure is.

165. To know how far the sun travels in one day against the horizon of the zodiac.

166. That the length of the year is reckoned by the revolution of the sphere of the fixed signs, and not by the figure-bearing constellations; and whether the measure of the year stands at one fixed value.

167. That the sun's sphere has two orbs encircling the globe of the earth.

168. That the two solar orbs mentioned are described as three orbs.

169. The form and structure of the fourth firmament — which is the sun's sphere — and how its thickness divides into three orbs.

170. That the middle white circle, and the sun itself, both touch the sphere of Mars.

171. Explanation of the line of the sun's course (the ecliptic), around which it always revolves and from which it never deviates.

172. Five linear circles are found in the whole depiction of the aforementioned solar sphere, and the eccentric center (*merkaz hayotze*) inscribes a circular line around the center of the world.

173. How much is the thickness of the [solar / first] sphere [?]. [source: " של גלגל נוש א'" — garbled]

174. The reason why the three solar orbs differ, each one from the other.

[Foot of page: ****]

Source page 11, left column (continued)

175. Explanation of the saying of the Sages, of blessed memory, that the sun and moon are in the second firmament (*Rakia*) [cf. Talmud Chagigah 12b].

176. That the three dark orbs mentioned — each of them has two centers.

177. That the middle orb in the sun's sphere is fully eccentric (*yotze merkaz*), and by its revolution alone the length of the year is reckoned.

178. That the sun draws near to and recedes from [...] the center of the earth. [word garbled: "מכדו' ומרכז הארץ" ?]

179. That the inert[?] sphere in its entirety — namely the two dark orbs of the figure, according to the opinion of Ptolemy [בטלמיא"ם = *Ptolemaios* / Ptolemy] — has a heavy motion of its own, and it displaces the apogee (*rum govah*) of the sun.

180. That the center of the eccentric sphere also moves from its place.

181. That the sun's sphere has four motions.

182. Which is the mean position (*emtza'i*) of the sun in the zodiac and which is the true position (*amiti*), and the difference between the two positions.

183. That sometimes the mean motion precedes the true, and sometimes it lags behind.

184. That the sun revolves with equal motion in two differing times, or with differing motions in two equal times.

185. That the four seasons of the year, according to the sun's true motion, are not equal to one another.

186. That for the reasons mentioned, the lengths of the natural days also differ.

187. Explanation of the difference in time between the true season and the mean season.

188. Explanation of the moon's sphere and the arrangement of its orbs.

189. That the moon's deferent (*galgal hanose*, carrying-sphere) is inclined from the [?] sphere toward the north and toward the south.

190. That [three?] distinctions are found between the inclination of the zodiacal sphere and the inclination of the inclined sphere.

191. On the motions of the [Dragon's] Head (*Rosh*) and its Tail (*Zanav*) — the lunar nodes. [source garbled: "מתנועות רא ש ה ו ר נין וזנבו"]

Source page 12 (folio ה verso)

192. That the moon's position in the zodiac is reckoned in the longitude of the firmament, and also in its latitude.

193. How much is the measure of the inclination of the moon's deferent from the [?] sphere.

194. Explanation of the matter of the epicycle-sphere (*galgal haqqafah*) belonging to the moon and to the other five wandering planets (*kokhvei nevukhah*).

195. The forms of the epicycle-sphere, and that the planets' [epicycles] also touch the sphere above it and the one below it.

196. That the moon's motion in its epicycle is the reverse of the motion of the other epicycle-spheres, and is called "the moon's retrograde motion" (*bechilluf*).

197. On the regions (*galilei*) of the moon and the regions of the other wandering planets.

198. On the difference found in the moon between its mean position in the zodiac and its true position.

199. The difference between the true motion and the mean.

200. All the differences found in the sun by reason of the eccentric sphere — all of them are found in the moon by reason of the epicycle-sphere.

201. That the moon's spheres have [six?] motions. [numeral uncertain]

202. That the reckonings of the seasons (*tekufot*) and the conjunctions (*moladot*) were established for us by Chazal according to the mean motion.

203. On the time of the moon's revolution in its sphere, the time of the revolution of its epicycle-sphere, and the length of the lunar month.

204. The reason for the difference between the time of the moon's revolution in its sphere and the length of the [synodic] month.

205. That the moon revolves in two equal times with two differing motions.

206. That by the causes of the moon's revolution around the globe of the world, the moon itself makes a circular orbit-path that is [shared?] and greatly tangled.

207. That the body of the moon makes many distinct circles and orbits, intertwined and greatly tangled, most of which are without number.

208. The difference between the line issuing from the center of the earth and the line issuing from the pupil of the observing eye, which stands upon the surface of the globe of the earth (i.e., parallax).

209. The definition of the molad (conjunction), its nature and time, and the many causes of the variations found in the moon throughout the days of the month.

210. The forms and measure of the moon's waxing and waning, and how many hours it remains above the horizon all night.

211. That the reckoning of the hours mentioned nearby is specifically according to the reckoning of the seasonal hours, and the reasons for fixing these hours.

212. On the time of the moon's concealment (*setirah*) each month, and the cause of the lateness and earliness of its sighting.

213. The length of the lunar month, which is 29 [days], 12 [hours], 793 [chalakim] [כ"ט י"ב תשצ"ג = 29 / 12 / 793] — from where it is known to us.

214. For which place on earth the reckonings of the conjunctions and the seasons were established.

215. That after the renewal (new moon), the moon appears above the horizon always by the same measure [?].

216. That no star completes a full revolution in the time of one revolution of the daily sphere.

217. To observe the voluntary motion (*tenu'ah retzonit*) in all seven wandering planets.

218. That no contrary (retrograde) motion is found — neither in the [planet], nor in the eccentric sphere, nor in the epicycle-sphere. [one word garbled: "ולא'בכיו"']

219. How high the moon is above the center of the earth, and the difference between its nearest and its farthest distance from it.

220. On the eclipses and darkenings of the moon.

221. The nature of the shadow of light, which goes tapering to a point, and that when the moon enters it, it is eclipsed.

222. The forms of the moon's second[?] deferent circle, and that every eclipse occurs at the Head (*Rosh*) of the nodes, or at its Tail (*Zanav*).

223. Why the moon is not eclipsed every month, [even] when its center is opposite the center of the sun.

224. That sometimes the darkening is found not in the whole moon but only in part of its body, and when the moon escapes the eclipse.

Index of the Paragraphs (מפתחות לסימנים) — continued

(Two-column list; reads right-to-left in the source, right column then left column, continuous. Paragraph numbers are given as printed in Hebrew letter-numerals, with the Arabic value in brackets. This batch completes the index, running from the tail of siman 224 through siman 305.)

(224, completing the previous entry:) … eclipsed completely (הלקוי לגמרי).

- **Siman 225 (רכ"ה)** — That the astronomers divided the stages of a lunar eclipse into five periods.
- **Siman 226 (רכ"ו)** — On the eclipses of the sun, and that there are several [differences] between its eclipses and those of the moon.
- **Siman 227 (רכ"ז)** — That the cause of a solar eclipse is that the moon stands before the sun and cuts off its light.
- **Siman 228 (רכ"ח)** — How the moon, small as it is, can block the sight of something larger than itself — by more than [numeral: ?] times.
- **Siman 229 (רכ"ט)** — Why an eclipse does not befall the moon every month.
- **Siman 230 (ר"ל)** — That a solar eclipse is seen in one place entirely, in a second place partially, and in a third place not at all.

- **Siman 231 (רל"א)** — How much time falls between one eclipse and the next, and how many eclipses are possible in a single year.
- **Siman 232 (רל"ב)** — The reason the planets ("wandering stars") sometimes move forward, sometimes backward, and sometimes stand still. [retrograde motion and stations]
- **Siman 233 (רל"ג)** — The reason we see one star remain fixed in its place, going nowhere. [the celestial pole]
- **Siman 234 (רל"ד)** — That all the stars are hidden beneath the light of the sun, and the manner of their entering and emerging from beneath its light.
- **Siman 235 (רל"ה)** — Why the planet Venus (Nogah) is sometimes seen before the sun, sometimes after it, and sometimes not seen at all.
- **Siman 236 (רל"ו)** — That the planet Mercury (Kokhav) too behaves like Venus, one and the same rule applying to both.
- **Siman 237 (רל"ז)** — The three upper planets — namely Saturn, Jupiter, and Mars (שצ"ם) — how they lie beneath the light of the sun.
- **Siman 238 (רל"ח)** — Whether the light of the stars is their own or acquired from the light of the sun.
- **Siman 239 (רל"ט)** — How great is the bulk of the body of each of the seven planets, relative to the body of the globe of the earth.
- **Siman 240 (ר"מ)** — The table of periods in which the carrying-sphere (deferent), and also the sphere of revolution (epicycle) of each of the seven planets, revolve about the globe of the world.
- **Siman 241 (רמ"א)** — How great is the inclination of the [six] planets from the middle line of the zodiac, across the breadth of the firmament, toward north and toward south.
- **Siman 242 (רמ"ב)** — On an instrument called the quadrant (keli ha-rova), for measuring the altitude of the pole (tzir) and the altitude of the stars.
- **Siman 243 (רמ"ג)** — That the quadrant works by one of two methods; and an explanation of the first method.
- **Siman 244 (רמ"ד)** — How measurement is performed with the quadrant.
- **Siman 245 (רמ"ה)** — That everything lying on the line of sight (kav ha-nitzotz) — even if one object is larger than the other by a thousand parasangs — is reckoned at a single altitude for both.
- **Siman 246 (רמ"ו)** — The manner of making and calibrating the quadrant according to the second method.
- **Siman 247 (רמ"ז)** — The figures and diagrams of the quadrant, with all its rules and specifications.

- **Siman 248 (רמ"ח)** — To find the sun's altitude — how far it stands above the horizon.
- **Siman 249 (רמ"ט)** — That observing the altitude of the stars is done by one of three methods.
- **Siman 250 (ר"ן)** — To find how high the northern pole rises above your horizon, in every place and at every time.
- **Siman 251 (רנ"א)** — Another method for finding the pole's altitude in every place, quicker and easier.
- **Siman 252 (רנ"ב)** — To find the altitude of the northern pole itself by the sun's course, on the days of the Nisan and Tishrei equinoxes, in every place, whether at sea or on land.
- **Siman 253 (רנ"ג)** — To find the pole's altitude in every place by the sun's daily course throughout all the days of the year.
- **Siman 254 (רנ"ד)** — That the calibration of every observational instrument (keli machazeh), in every place, must accord with the pole's altitude there.
- **Siman 255 (רנ"ה)** — To draw upon the face-plate of the instrument three principal arcs — one for Aries and Libra, one for Capricorn, and one for Cancer — and how high the sun stands in each of them.
- **Siman 256 (רנ"ו)** — To draw upon this quadrant a meridian (midday) arc.
- **Siman 257 (רנ"ז)** — To draw, as with a compass, a circle or an arc that passes through all three points, however they lie — provided they do not all lie on a single straight line.
- **Siman 258 (רנ"ח)** — To know the sun's altitude at the head of each of the twelve zodiac signs of the firmament.
- **Siman 259 (רנ"ט)** — The manner of squaring the arc of the zodiac and this quadrant.
- **Siman 260 (ר"ס)** — Finding the sun's place in the zodiac by means of the quadrant, at any time throughout the year.
- **Siman 261 (רס"א)** — To find, throughout the year, how far the sun or any other star has moved from the straight line (the equator).
- **Siman 262 (רס"ב)** — To know the distance of each star from the point opposite the zenith (nokhach nekudat kodkod).
- **Siman 263 (רס"ג)** — To know, when the sun enters the head of each sign, how high each sign stands above the horizon at every hour of that day.
- **Siman 264 (רס"ד)** — The reckoning of the day-hours in [the visible half of] the sphere, and that they begin from midday.

- **Siman 265 (רס"ה)** — Calibrating the hour-arcs on the quadrant. [printed defectively as "יס"ה"; sequence confirms 265]
- **Siman 266 (רס"ו)** — That not all the hour-arcs are always constructed according to all the aforementioned principal arcs.
- **Siman 267 (רס"ז)** — To know the times of the sun's rising and setting, and the measures of the lengths of the days and nights throughout the year.
- **Siman 268 (רס"ח)** — To know, on any given day, whether it is the time before midday or after midday.
- **Siman 269 (רס"ט)** — To know, at any time, how many [equal] hours have passed since [daybreak].
- **Siman 270 (ר"ע)** — To know how high the pole stands above the horizon of the place where the quadrant was made.
- **Siman 271 (רע"א)** — An explanation concerning a fixed (vertical) star (kokhav nitzav).
- **Siman 272 (רע"ב)** — Likewise, from the above.
- **Siman 273 (רע"ג)** — An explanation of calibrating an observational instrument.
- **Siman 274 (רע"ד)** — An explanation of the method of measuring the breadth of a surface lying on level ground.
- **Siman 275 (רע"ה)** — An explanation of extending the perpendicular line so as to make the measurement precise.
- **Siman 276 (רע"ו)** — An explanation of the method of measuring the height and elevation of towers [המולות; likely "towers"; ?] or other things.
- **Siman 277 (רע"ז)** — An explanation of when the sighting-vane (moreh) cuts the upper axis of the instrument.
- **Siman 278 (רע"ח)** — An explanation of how one measures the height and elevation of a tower when one can neither approach the tower nor see its base or foundation.
- **Siman 279 (רע"ט)** — An explanation of the manner of measuring [down] from a mountain to a valley.
- **Siman 280 (ר"פ)** — An explanation of three kinds of measurement from the mountain to the valley (emek).
- **Siman 281 (רפ"א)** — An explanation of measuring when you cannot walk backward — as in measuring from a tower down to the valley.
- **Siman 282 (רפ"ב)** — An explanation of novel measurements by means of observational instruments when they are laid flat, together with their great usefulness.

- **Siman 283 (רפ"ג)** — An explanation of measuring by means of two different stations [?] on this side … height and elevation. [reading uncertain]
- **Siman 284 (רפ"ד)** — An explanation of finding the distance between the summit-points of two towers, even when you cannot approach the points of their tops.
- **Siman 285 (רפ"ה)** — An explanation of finding the measure of a tower's height by means of its shadow, in a very easy way.
- **Siman 286 (רפ"ו)** — An explanation of knowing a tower's height by means of its shadow, apart from the measure of your own body.
- **Siman 287 (רפ"ז)** — Easy and simple height-measurements for the builder [כפרייו"א ?], for which there is no [need of] any science of measurement (geometry). [foreign token unresolved]
- **Siman 288 (רפ"ח)** — To find [the point] opposite a tower, a tree, or another building, by means of a spear or a staff, without any instrument.
- **Siman 289 (רפ"ט)** — What the matter of the comets (kokhvei ha-zenavot, "tailed stars") is — called in the language of the Sages (Chazal) *kokhvei d'shavit*. [cf. Berachos 58b, כוכבא דשביט]
- **Siman 290 (ר"צ)** — Where the comets are located in the firmament.
- **Siman 291 (רצ"א)** — The cause — from what and whence the comet comes into being; why it appears suddenly and little by little wanes and fades; its cause as well; and the nature of thunder and lightning, explained incidentally (agav gerara).
- **Siman 292 (רצ"ב)** — The courses, or the revolution, of the comets.
- **Siman 293 (רצ"ג)** — How long a comet stands and remains visible.
- **Siman 294 (רצ"ד)** — In which region of the firmament comets usually appear.
- **Siman 295 (רצ"ה)** — That in most years comets appear … or other celestial signs.
- **Siman 296 (רצ"ו)** — Whether it is possible for the astronomers to know and foretell a comet before it comes.
- **Siman 297 (רצ"ז)** — Whether eclipses of the luminaries herald or foretell evil decrees.
- **Siman 298 (רצ"ח)** — Whether the astronomers' predictions necessarily come to pass, or whether there is found in them false portent and delusion (*mas'et shav u-madduchim*; cf. Eichah 2:14).

- **Siman 299 (רצ"ט)** — A small and brief note on the matters of the 28 (כ"ח) mansions of the moon, called [Latin] *mansiones lunae* (מאנציו'אנוסלינ"א).
- **Siman 300 (ש')** — The aspects of the zodiac signs, called *aspectus* (אשפעקטו"ס).
- **Siman 301 (ש"א)** — On the usefulness of the aspects (gazings) of the stars.
- **Siman 302 (ש"ב)** — On the value of the square (quadrate) aspects — what benefit we have in them [beyond the rest]. [reading partly uncertain]
- **Siman 303 (ש"ג)** — The nations, kings, and many regions into which Europe (ארופ"י) is divided, and the head of which zodiac sign each is assigned to.
- **Siman 304 (ש"ד)** — Whether the nation of Israel is placed under the dominion of the stars.
- **Siman 305 (ש"ה)** — The names of the 36 (ל"ו) celestial figures (constellations), and the number of their stars.

End of the paragraph-index entries (סליק סימני המפתחות).

Introduction of the Rabbi, the Author, speaking in clear language (הקדמה להרב המחבר בשפה ברורה מדבר)

He declares (אמר): I saw it as fitting [חובה] to reveal to the ear of the reader of this book of mine who the men were who began to seek wisdom in the matters of this exalted and profound science — that is, the science of the stars and the constellations — and to trace the root of its ancestry down to the present day, whether among the Children of Israel or among the nations [of the world].

Know (דע) that long ago I found [מצאתי; ?] in the holy books that [the Sages] grew wise in this science; [that already] our father Abraham, peace be upon him, [was expert in it], for so they testified of him — [as our Sages of blessed memory, the masters of the Talmud, who were of profound learning; great was Abraham in it], as it is said at the end of a chapter [chapter name ?] of tractate Shabbos: that Abraham said before the Holy One, blessed be He, "Master of the Universe, I have looked into my astrology (itztagninut), and I see that I am [not] fit to beget a son…" [Shabbos 156a]. […] [כאמר … מלך ?] And after Abraham, our Sages, peace be upon them, we find [that they too were expert]. [… as in] the verse "and of the sons of Issachar, men who had understanding of the times" [Divrei HaYamim I / 1 Chronicles 12:33]. We find a great allusion [in the Talmud ?] that [the Sages] were

expert in [the reckoning ?] [...] and in the fixing of the festivals — which would be impossible unless they knew the science of the courses of the stars, as [Rabbi ...] and Rabbenu Yitzchak Abarbanel [Isaac Abarbanel] illuminated concerning this in his new commentary.

After them, [the like of ?] Solomon the King, peace be upon him, was outstanding in this science — apart from what is written of him in Kings I [Melachim I], where the Holy One said to him, "Behold, I have given you a wise and understanding heart, [so that there has been none like you before you, and after you none shall arise like you]" [1 Kings 3:12], and where it says "and he was wiser than all men" [cf. 1 Kings 5:11] — which shows and proves that he was outstanding specifically in this science.

And I found written in the book *Chochmat Shlomo* (the Wisdom of Solomon) — which is one [chelek ?] of the eight books [composed by ?] [...] — [that in] chapter 7 [Wisdom 7] they relied [on it], and this is its language: "[When I prayed], wisdom was given to me, and precious it is [above all kingdoms], and all wealth is as nothing beside her, and all my precious desires [...] beside her; gold [I esteemed] as mire, and silver shall be reckoned as dust; [...] the desirable light [that comes] from her does not [dim]," etc. — until it further says there: "God gave me knowledge, and I saw that I know the structure of the world (tavnit ha-olam), and the nature of the elements, and the measures of the times — the beginning, the middle, and the end — [and] the changes of the days and the cycles (galgulei) of the year's seasons (tekufot), and the positions (te'udat; ?) of the stars." Thus far [the quotation].

And Nachmanides (the Ramban), in his introduction to his commentary on the Torah, also proves this matter [... like the Wisdom of Solomon ...]; and this is his language there, in the aforementioned introduction: "And I saw a book, translated, called *Chochmeta Rabta d'Shlomo* (the Great Wisdom of Solomon), etc.," until: "and it said that God is the Giver of a knowledge in which there is no falsehood — to know how the world came into being; the constellations (mazalot) He named, and also the diagonals (alachsonot) and the tails (zenavot) [comets / nodes], and how they [move] in their seasons; the courses of the heavens and the movements of the stars [...]." The two versions accord as one, and [the book] encompasses the whole science of astronomy.

And although the book *Chochmat Shlomo* is not canonical for us like the rest of the [Holy] Writings — for the nations are not to be trusted regarding the Holy Writings, since [... perhaps their hands touched them deliberately, by addition or subtraction ...] — nevertheless, examine the matter and you will see that

Nachmanides, of blessed memory, testified concerning [this] matter in his aforementioned introduction, and saw fit to rely on it and to draw support from it, [in the manner in which] the Sages [in Midrash Tanchuma / Shir HaShirim Rabbah] on the verse "I planted myself vineyards" [Kohelet 2:4] [relied], where they said that [Solomon] knew the plantings and the key of the whole world.

And in our Talmud we find [regarding] R. [Chiya?] the Great, son of [Sorkbes / ?] [...] *[the sentence is cut off at the foot of the page and continues in the next portion].*

הקדמה — Author's Introduction

[The introduction runs in two columns per page, read right column then left. Internal rubrics are set as bold lead-ins.]

It is well known that some assert that the words of Chazal in the science of astronomy were not spoken by them as received tradition (*kabbalah*) — that, apart from what bears on the calendar-intercalation (*ibur*), they spoke only according to their own reasoning, as their eyes saw, and not by way of tradition. And they say that Chazal themselves admit their lack of knowledge in this science, bringing a proof from Midrash Rabbah, Parshas Bereishis, ch. 6 [*so I read* מד"ר], where it is said, concerning those who receive [i.e. track] the cycles: Rabbi Shimon bar Yochai said, "We do not know whether they [the heavenly bodies] fly through the air, or whether they [run] across the firmament, and from where [they move] on their course. The matter is very difficult, and it is impossible for creatures to grasp it" (end of quotation).

And the pious one, my teacher and master who taught me and raised me, our teacher Moshe Isserles [the Rema], of blessed memory, was likewise stirred by this in his book *Toras HaOlah*, part one, ch. 22 [*I read* פכ"ב], and these are his words: "To this one might say that the words of the Sages are received traditions, and perhaps that is so — we shall not dispute it, for if they are tradition we accept it, though it be far from reason; but [if it be a matter of reason,] there is an answer. And whatever can be interpreted so that the words of the Sages do not conflict with what is well established, and to draw them near to reason — how good and how pleasant it is." And he added there that whoever [cares] for the honor of his Maker and the honor of the Sages of Torah will scrutinize their words closely, so as not to [suppose]... that they knew the secret of understanding better than the sages of [?] [end of that chapter]. Also in ch. 28 of that part, and in other chapters besides, he brings several matters from [the Sages'] words which

at first study seem to run against the well-known reasoning [?]... he set before our eyes a fitting resolution, "like apples of gold in settings of silver" [Mishlei 25:11].

Know, too, that great and famous sages have already labored much and excelled in this — to settle the words of the Sages properly, so that they not conflict with the well-known [system] [?]...

[The Jewish authors of astronomy.] And the people known among our nation who excelled in wisdom, who [studied] and composed and wrote books from it: the great Rav, the Rambam [Maimonides], of blessed memory, [in his *Hilchot Kiddush HaChodesh*] [?]... the great scribe R. [?] — his works I have not seen. And R. Avraham bar R. Chiya [Abraham bar Hiyya], [who covered] the whole "form of the earth" [*Tzurat HaAretz*]. And R. Y. Israeli [Isaac Israeli], who composed *Yesod Olam* and *Sha'ar HaShamayim*. Gershon, namely the Ralbag [Gersonides], greatly expanded on it in his book *Milchamot HaShem*, in the fifth article of the first part — but the printers omitted it and left [a gap] [*so the sense*; המדפיסים השמיטו], as [he says]... it is so large a book; and I have not seen half of the text to this day; and whatever doubt entered [regarding] the authors besides them — but I have not seen it [?].

And now I shall open the ear of the reader to what I found in other books concerning the chain of transmission of this science [?]. And know that I found written in the book of Yosef ben Gurion [the *Yosippon*]:

that Solomon the First [King Solomon] was an outstanding sage and a great genius in the science of astronomy, and he excelled greatly in his composition on it, and so too [his forebears] [?]. And as the wise son wrote in the *Yosippon* concerning Abraham our father, peace be upon him: that when he went down to Egypt because of the famine, in ancient days, while he dwelt among them, he taught the sages [and the magicians] the science of number [arithmetic] and the science of astronomy; and he excelled, [to judge] from the praise the Egyptians gave him for the greatness of his intellect in both sciences. To this the words of Chazal, the sages of the Talmud, also lend support, as they testified at the end of the last chapter of [Bava Basra] [?]... a great [man] he was. And [our forefather] Abraham, peace be upon him, transmitted this science to his son; and his grandsons — they were Isaac and Jacob — and it is written that Job, too, was in those days, and he likewise [knew] twofold of this science; and this too is a matter close to belief, for he mentioned several things and matters of the science of the stars and the constellations, as [in] "He makes the Bear, Orion, and the Pleiades" [*Iyov* 9:9], and "Can you bind the chains of the Pleiades, or loose the belt of Orion?" [*Iyov* 38:31], "[can you bring out] the constellations in their season?" —

see there regarding [all of them], in ch. 38 [of Iyov]. And although these verses are the utterance of the Holy One, blessed be He [to Moshe] [?]... "the word of the Lord to Job" — matters that [he could not comprehend]; and from there onward they wrote out the chain of its transmission, as we shall explain.

The Egyptians received the science of number [arithmetic] and geometry, together with the science of astronomy, from Jacob and his sons when they went down to Egypt, as I wrote above — what [the sons] had already received from Abraham our father, peace be upon him; and [the Egyptians] learned from them what they had received from their fathers, from Abraham and Isaac, and, with the abundance of the traditions there, this science took root and [found favor] among the children of Israel [?], and it remained in the hands of the magicians of Egypt, who excelled and grew very great in it. And the sayings of Chazal also support this, in mentioning [that Pharaoh] [?]... [was learned] in wisdom in [several] places; and researchers have written that in Egypt there was an ancient [tradition] in the science of the sphere, before all who built [towers] [?], and they excelled in it more than every other land, people, and tongue under all the heavens. And this was for three causes:

The first — their reception [of it] from their fathers Abraham, Isaac, Jacob, and his sons, as mentioned. The second cause — that it is well known that the river Nile rises every single year and waters the land, and raises upon their soil silt and mud that spreads out [?], nourishing the [sap] of the heavy [soil] [?]... [and returns and reaches every plot], and [each man] measured his soil by means of the science of number and the science of measurement, which is called (**geometry**) [Greek: γεωμετρία, "measuring of the earth"] — that is, the parceling and measuring of the land. And from this science they gained understanding and rose ever higher in intellect, until they arrived at the science of astronomy — the courses of the seven wandering stars [planets] and the courses of the constellations — which to this day, the measurements and inquiries of stars and constellations, is called, according to the sages in all lands, after that which it began with, (**[astronomia?]**) [*so I read* ניאוטמי"טריאה; the printed token is unclear], whose meaning is "the measuring of the earth" [?]. The third cause, which remained [?]... that in [other] lands it is not in the astronomers' power to persevere in the observation of the stars, for when the clouds fill [the sky] with rain, no star at all is fit [to be seen] for them — which is not so in the land of Egypt, since rain is not found [there]; also when travelers report to us, and as we see from the verse — for it is written, [in Moshe's saying,] "not like the land of Egypt" [Devarim 11:10] — Scripture spoke at length of their wisdom, saying of Solomon, peace be upon him [Melachim I 5]:

that [his wisdom exceeded that of] all the children of the East and all the wisdom of Egypt [Melachim I 5:10], and [the commentary] there explains [?]... the science of the constellations.

The Greeks received the science from the magicians of Egypt, the sages who were there, and this science remained among the Greeks a long time. And [I give here] some particulars of the names of the ancient Greek sages who were among their chosen [?]: as [at the time of] the Trojan War, which was in [the days of] the judging of the Judges [?], there was an outstanding astronomer called Kidon [?] [*garbled*], and [?]... [who gave] names to the [luminaries] of the heavens; and Siron [?]; and [one] who was in the days of Daniel; [?] Silom [?], from the city Vinilo [?] in the land of Greece, who was the first to write on the causes of eclipses of the luminaries and their [phases] [?]. [Note: this run of Greek astronomer-names is badly garbled in the print; the individual names cannot be identified with confidence — see QA.]

[Hipparchus?] the great and famous, who excelled in this science beyond all [the men of] his generation, such that there was none like him. Two great and famous sages were [?]: (Iteagris [?]) [*garbled*], in the year (11[?] [reads ~117 ≈ קי"ז, but embedded in a garbled proper-name string — not clearly a year; Stage-5 corrects the earlier "107" over-commit] [?]), who [?]... they wrote and acknowledged that they received the science from the Jews who [?], [together with] the Egyptian sages and many great and hidden [sages] [?] and others; all of this was in the great and renowned city (**Attica**) in the land of Greece — that city, from the day of its founding, was mother and metropolis to all [wisdom]; from it all wisdom went forth, from the academies of the sages permanently settled there. This is also [reflected] in the words of Chazal, in the tractate [?]... [and likewise] in tractate Bechorot, regarding [the year] [?], the matter of Athena/Athens [*so* אתונא], (the [elders] [?]) they are (the [wise] [?]) [cf. Bechorot 8b, the elders of Athens].

[The] men of the province of Babylon and [Galilee?] [?] received and learned this science from the Egyptians, and from the Greeks and [?]... from the chief sages of the ancient Chaldeans who were in the land of Shinar [?]: (Timokdos [?]) and the second named (Aristolum [Aristarchus? / Aristotle?] [?]) — they were about fifty [years] [?] before the kingdom of Alexander, near the year 400 of the fourth millennium [?]... the first whom we know to have carefully investigated the star of Saturn [?]... in a book [?]... for many days, by means of (Hipparchus) and Ptolemy the Chaldeans [?], who spent many days and cycles on this science and greatly excelled [?]. And thus [it is said], concerning the motions of the Chaldeans,

at the end of the last chapter of [tractate] Shabbos [?]... Know that of all the sages mentioned, no book was made public [?] among us — only [in the treasuries] of [their] teachings [?] — [covering only] a portion of the science.

Therefore I shall set forth further some of the great sages by name who were in the land in the days of the First Temple, until [its destruction] [?] — who also [carefully] examined and observed the courses of the luminaries, and composed and wrote their deeds in books that became famous [among us]... to this day:

(**Euclid**) was a man in the time [of] the famous sage [?]... [surpassing] in intellect all who were before him [and after], [and] to this day there has been none like him. He composed the famous [book] known by his name (Euclid's [*Elements*]) [?], which he investigated to its depths, in such a manner that all the great sages, ancient and later, as one [attest and] declare that [there is not] in the sciences a book beneath the heavens greater than it, or equal to it [?], in the [grades] and sharpness of its teachings — [yet] as regards matters of astronomy [and the mathematical sciences], [it treats little] [?]... in his great book, of matters of astronomy only a little, [not enough] to [gladden us] [?], nor did it fill our hands and [those of his students] with anything of astronomy at all, for this book of his is like a hall [?]... [?].

(**Archimedes**) the outstanding, well-known sage, whose compositions too [are known] in the world, since he excelled [as] our sages [say] [?]. In all the sciences he was an outstanding astronomer and geometer; he was [outstanding] [?]... [he reckoned] how many grains of sand the whole world holds [*the "Sand-Reckoner"*]; from the center of the earth up to the sphere of [?], he made a globe [?] so large that one could enter it and sit at its center, and round about it were depicted [?] all the stars of the heavens. He dwelt in the city of Syracuse [סירקוסליית], which is in the land of Greece [*recte* Sicily; the author writes "Greece"], near the year 500 of the fourth millennium [?]; he was [?] the height [chief?] of the city [?]. There was also [another] outstanding sage near his time, called (Aristarchus of Samos [אריסטיקום סרי"וס]), who likewise gave motion to the globe of the earth [i.e. proposed the earth's motion].

(**Hipparchus**) was the great and famous astronomer called [?] Kiparkos [Hipparchus] — he is the man whom Ptolemy cites, and they said of him that he was more discerning and clear in the craft [of astronomy] [?] than all the researchers before him, as the author of *Yesod Olam* wrote, in gate 3, ch. [?] — (Hipparchus). This is according to what the author of *Sefer HaYuchasin* wrote of him, on folio 14 and [25], [and] in *[Me'or] Einayim* [?], ch. 40 [?]: he [examined] all the ancient reckonings from [the past] 400 years up to the eclipse of the moon,

and fixed the hours, parts [*chalakim*], instants [*regaim*], and the fine fractions, until his reckoning as a whole agreed with the reckoning of Chazal for the measure of the [mean] month — which is 29 days, 12 hours, 79[?] *chalakim* [כ"ט י"ב תש[צ?]"ג; the middle letter is worn — 793 is the canonical molad interval, but the glyph is not committed on the scan]. And he wrote further there that this is [the basis of] the secret of the lunar cycle in the [19-year] cycle of intercalation.

This sage [Hipparchus] dwelt in the city of Rhodes [רוד"י], which is in the land of Greece. As to his date there is some doubt: for according to the author of *Sefer HaYuchasin*, folio 117, and according to the author of *Me'or Einayim*, ch. 46, he was in the year 4534 [?] of the [fourth millennium]; [yet] from his composition it is evident that he was in the year 4634 [?] of the fourth millennium — [?] in the days of [?] — [?] of the Seleucid era, 227 years [after] the building of the Second Temple, and 134 years before the destruction; [and] 134 years before, and 186 [?] years [into] the Seleucid [era], 226 years after the building of the Second Temple [?].

[The Julian calendar reform.] Near his time [?], there was, [in the time of] Caesar Julius [יונליהו"ם = Julius], two outstanding sages: one named [?] [Clupo?] and the second named Sosigenes [סוסי"נעס], upon whose word the emperor fixed the measure of the year at 365 days and a quarter, according to which they conducted [the calendar] in all lands from his time [for?] [?] years. And we have already treated this at length in gate [9?] of our book *Me'or HaKatan*, and here is not its place.

(**Ptolemy**) [כטולמי"אום] the great, [wondrous], and [gifted] sage, whose like there was not before him or after him to this day. He gathered and collected from the books of the Greek and Chaldean sages of the stars, and from the books of the other sages before him, many things, great and deep innovations, and he excelled in writing on this science more than all before him, and set it all down in a book — that is the famous book, the *Almagest* [למגסטו"ן(א)], [?] of Egypt; and all the figures of his teachings [he set down] according to the manner of the reckonings [?] of that city, as is explained in the said book of his. The sealing [completion] of his book was in the year 500 of the fourth millennium [?] [= year 140 of the Christians], in the days of the pious Antoninus [אנטונינו"ס], about [?] years after the aforementioned great astronomer [Hipparchus]; and from his day to now it is [?]... and all the doubt [?] that is in Ptolemy [?]...

[Ptolemy, continued.] He also learned many of his astronomical teachings from the sages of Israel, for it is already known that the children of Israel were a mighty and numerous people in exile, [and] many, in Alexandria [אלכסנדריא"אם]

of Egypt, and [?]... some expositions [?]... and this was [the seat?] of the Sanhedrin [?]... in a baraita of the Jerusalem [Talmud], and it is proven from [tractate] Sukkah that, accordingly [?]... and he received from them many things.

The said Ptolemy was called by his [given] name Claudius [קלודיא"וס], and "Ptolemy" too was an epithet. For it is already known that from the days of Alexander of Macedon the name "Ptolemy" was ascribed to the kings of Egypt — as, of old, the name "Pharaoh" [was applied] to [the kings of] Egypt, and "Darius" to Persia [?]. And [because] this man was of the lineage of the kings of Egypt, they called him after their name "Ptolemy," since the Romans had already taken the whole kingdom of Egypt into their hands by force, about 170 years and [?] before this time — as the great inquirer [related]: (Titus [?] [טיטא כרא"סי]) [?], he told his tale [?], and said the Romans took the kingdom of Egypt from the [dominions] of (Ptolemy) by force; [thereafter] they [the Ptolemies] sank lower and lower, ruling and impoverished, until they lost their kingdom; and so [?] this [was] another kingdom, for good and great [?]...

a thousand parts, [at times] he took into his hand however much he brought under the dominion of his intellect — all three parts of the world, [the lower one] [?] — and all this not with an army and a great multitude, and not in wars of lions [?] and [?] in battle, and not by sword and not by bow, but with a scribe's pen alone he did all this. Nor was that enough for him, until he rose in his intellect above all seven firmaments, up to the eighth firmament, and inscribed for himself in true writing the images of the whole zodiacal belt and the other figures and images of the heavens — in such a way that this Ptolemy rules by his intellect over the lower and the upper [worlds], and this kingdom rises ever higher and endured in his hand; and all the dwellers of the earth — kings and princes of the land, the discerning — are as those subdued beneath his dominion, and they set a memorial crown upon his head, from days of old to this day and to the end of all generations.

(**al-Battani**) [אלבתי"יגו] the Arab, the great sage, called by the astronomers [?] [al-Battānī], walked in the footsteps of Ptolemy, and greatly excelled in this science, and made pillars for it, and innovated in it precious things... in this, in an honored place; and he [renewed] precious tables and an honored, wondrous reckoning for the science of astronomy, which he made for [its foundations] [?], as is customary in them to this day.

I also found in the *Hilchot Kiddush HaChodesh* of the Rambam, of blessed memory, that he founded most of our reckoning upon the reckoning of the said famous al-Battani [Rambam, *Hilchot Kiddush HaChodesh*, beginning of ch. 17] [*I*

read ראש סי' י"ז]. The making of his tables was in the year [880 — reads תת"פ; Stage-5 cold audit corrects the earlier "480/ת"ף" misread (a dropped tav)] of the Christians, which is the year 4640 of the fifth millennium [AM = 880 CE — the two figures now agree, the historically correct al-Battānī date], and this is the year after our teacher [the Rambam] composed [?]... — and the time of Ptolemy's composition [was] [?] years [earlier].

(**Alfonso**) [אלפונ"סי] king of Spain and Portugal [*recte* Castile], was outstanding in the science of astronomy, and he had a great academy of sages to examine [under his patronage] the courses of the luminaries. They wrote of him that he spent on this science more than four hundred thousand gold pieces; he too renewed and arranged tables for the science of astronomy. The time of his composition was in the year 15 of the sixth millennium [= 5015 AM], which is the year 1225 of the Christians. And the author of *Sefer HaYuchasin*, folio 132 [?], wrote that R. Isaac ibn Sid [ר' יצחק אבן ס"ד] composed the astronomical tables for Alfonso king of Portugal in the year 11 of the sixth millennium [= 5011 AM], and after his [patron's] name his tables are called the **Alphonsine Tables** [לוחות אלפונגסי"ן] to this day. And [as for] [?]...

in a writing that I saw — and this in a book translated into the vernacular for King Alfonso, from the language of Spain into [?], into the holy tongue [Hebrew], by the Rav Jacob [ha-] [?] [יעקב הלקר"מי] in the year [4?] of the sixth millennium. And I translated from this book, from the Hebrew tongue into the Ashkenazi [German] tongue, the works of this great inquirer [?] [garbled], whose name will be mentioned further on.

(**Nicolaus Copernicus**) [ניקולאוס קופרניק"וס], also a man of Prussia [פרוסיה], a great sage, outstanding in the science of astronomy above all the sages of his time. The sages of our own time too, as one, attest to the [greatness] of his intellect and the depth of his understanding in this science, and they said of him that from the days of Ptolemy none like him had been found. This man — in his generation, [given] the depth of his wisdom and the surpassing novelty of his intellect — took it upon himself to demonstrate that the globe of the earth revolves in a perpetual spherical rotation. And this is no new thing, for even to the ancients, two thousand years ago, such a notion arose in their spirit; for I found in the book *[On] the Heavens and the World* [*De Caelo et Mundo*], in the second chapter of the fourth division, that such was the view of the wondrous sage Pythagoras [פיטגורו"ס] and his circle. And the sage Copernicus already composed on this a wondrous book, deep, deeper than [the sand], and [the intellects] [?]... his wondrous composition was in the year 1500 [?] of their count,

which is the year 5[260?] [?]. And the all-encompassing sage died in the land of his birth, in the province of Prussia [פרייסן], in the year 1543 of their count, which was the year 5305 [?] [ה' אלפים ש"ה].

(**And you**), honored reader — behold, even according to all that is related above, it is set out as though the root of the science of astronomy came to us from the [gentile] nations. Therefore know well that the matter is not so, for the root of the knowledge of this science first went forth from the children of our own people — as the Rav, our honored teacher [?], wrote in *[Or] HaTorah* [?], part 1, ch. 78, and as the author of *Derech Emunah* wrote, in [?] gate 3, and as the author of *Me'or Einayim* brings, ch. 20; also [it is shown] [?] that the science of astronomy was first in Israel. But when the exile among the nations came upon us, it came into their hands, and, being written in our studies [as coming] from them, they appear to be the first, and that it went forth from them, and "it became theirs" — thus far the Rav. For who among us is greater and more perfect than he who preceded [them] — [one] like whom there was none, and after whom none arose. And we have already revealed [?]... his glory in the science of astronomy. But his books, and the books of the other ancient sages, in matters of astronomy, we have not seen; and so the Rambam wrote, in ch. 17 of *Hilchot Kiddush HaChodesh*, that the books on astronomy composed by King Solomon, peace be upon him — rather, by the sages of Israel who were of the tribe of Issachar — did not reach us (end of quotation) [Rambam, *Hilchot Kiddush HaChodesh* 17:24]. And it may be that those very books came into the hands of the sages of the nations, and they [now] boast [?]...

that these ancients [drew] from the astronomy of earlier times, from hidden secrets [?]; they learned from them. The Rambam and the other authors received [?]... themselves admit this, [drawing] from ancient books; and though the science [preserved among us] is [?] and small in text, and [amounts only to] the toil of a few of the ancients — yet the intellect [is] in their books — [and] though it is not the whole of the science of astronomy, in any case it is but a gleaning [?] compared with the *Almagest* and the other books of astronomy in their hands.

(**And now**): even if we learn from them and from their books good things and innovations in matters of the science of astronomy, we lose nothing, nor is there any blemish in this at all. For we already find, in the chapter [of Rosh Hashanah?] [?], in the laws of [the willow?] [?], that Chazal themselves received the laws of the [drawing of the season] [?], and said that [certain traditions] were upheld [in the manner of] planting [?] and figs [?]... "those who smell the earth" [?]... — see there in Rashi's commentary. They also said, in the second chapter of Megillah:

whoever says a word of wisdom, even among the nations of the world, is called wise, as it is written, "from you [?]... and they said... sages." Chazal too ordained a blessing upon seeing them: "Blessed [are You]... who has given of His wisdom to flesh and blood," as it is [taught] in the chapter *HaRoeh* [Berachos], and it is brought so in *Orach Chaim*, ch. 226. And who among us is greater than our teacher Moshe [Maimonides], who wrote in the laws of...

Kiddush HaChodesh, ch. 17, and these are his words: "Since all these matters [rest] upon clear demonstrations in which there is no blemish, and it is impossible [for a person] to dispute them, we do not concern ourselves with who their author was — whether prophets composed them, or whether the gentile nations composed them; for concerning anything whose reason has been revealed, and whose truth has become known by demonstrations that have no blemish, we rely upon the one who said it or taught it, on the strength of the demonstrations that have been revealed and the reason that has become known" (end of quotation).

Several great ones of the world, too, among the later authorities, have composed [works], who from their days [?] studied the books of the gentiles and brought up their words and relied on their utterance in their compositions — [such as] the author of *[Sefer HaIkkarim]* [?], and the author of [?], and the author of *Yesod Olam* — and for benefit, as I said; each is good [?]... nor is any [more] fitting than they, especially as I have found [?]... perfect in wisdom; and this is what has come to hand for us through royal [patronage] [?]...

to expend upon them many thousands of gold dinars — as [did] Alfonso [אלפונ(ק)סי"ן] king of Portugal, and as, in this our own time, the emperor Rudolf [II], may his glory be exalted [רודלפו"ס יר"ה], has done, as explained above.

(**And now, in this** time) I have found two groups who speak with arrogance and have spoken defiantly against the science [of astronomy] and its students. The first group are wise in their own eyes, but [?]... do not set their heart to know, to understand, to gain insight, and to study these sciences, nor to inquire after [them]. Of them Solomon, peace be upon him, [said], as it were [?]... [and] because they [have not attained] its fullness, or the surpassing depth of this science, they reckon it [as] falsehood, and [light,] a matter of [delusion] and works of deception [?]. For this reason [they scorn] this science and its students [?]... Because they provoke them [the students] with mockery [?]... — [O you] who [pushed away] the knowledge of the ordinance of the heavens [?]. [You who fancied that,] like [certain] emissaries [?]... "you ascended on high," who "opened the gates of heaven" [?], gave a bribe to the keepers [?]... and to the keepers of the gates to admit you [?]... [it is] vanity; the Almighty [?]... to that which is revealed — your

deeds are [yours], and before [His] Name all of them are known [?]; and as their words [?]...

many. And the second group are [?] wise in their own eyes, and imagine [themselves masters] of this science, and teach that all my ways [are correct] [?] — yet nonetheless they have spoken defiantly against this science and its students, pouring out their mouth against it, saying that it is not fitting for a man to lose and waste his time on this science. They say: "What benefit is there in this science? Does one receive reward for it in this world or in the world to come? Does it yield from itself [rulings of] forbidden and permitted, or laws of money, or laws of plantings, or of betrothals?" Therefore I have resolved to know, to make known, and to make it known, how far they have strayed from the path of reason. For the benefits of this science are many and manifold, and I have seen fit to set down some of them in this book of mine. To this belongs the gathering-in of natural science from their [the gentiles'] books — which is what Chazal forbade, as they said in tractate Menachot, that it is forbidden to study Greek wisdom, [because] these matters draw the heart of the people to vanity, to strange views, and to corruptions. And [some] have already raised their voice like a shofar — [with condemnation] [?] and reviling and profanation — against the granting [of license] to the groups who read in the books of the foreigners who are not of the children of Israel, and [who are as] gentile offspring [?] — as is brought [?] in the Rashba, see there [?]... therefore, and [as] to their consolations, for [the matter] is loathsome [?], it is worse, at least, for them [?]...

matters and reckonings bound up with knowledge [?], and it easily inclines [a person] to turn from the path of truth, to entice toward heresy and [to gnaw at faith] [?] with heresy [*apikorsut*], as [?] excelled and grew great [?]... And the benefit [comes] from speaking [precisely] of matters — specifically in the science of astronomy — in order to understand and to demonstrate the laws of the sanctification [of the new moon] [?]:

The first benefit: It is already known that through this science there becomes known to us the mighty deeds of the One who spoke and the world came to be — as the [commentators] [?] and the Radak [R. David Kimchi] and others wrote on the verse, "The heavens declare the glory of God, and the firmament proclaims the work of His hands" [*Tehillim* 19:2], and as the sage, the author of *Sefer HaIkkarim*, greatly expanded on it in article 3, ch. 3.

Second: The sages, the authors of [works] among our [circle], have already written, in the cycle-books, of two [rotational?] motions [?], as was explained and made public [in the days of] the First Temple. And Chazal have already hinted to

us that [Abraham?] — whom [God] blessed [?], peace be upon him — through his wisdom in the science of the heavens, attained the knowledge of his Creator, as in the saying [of the parable]: he saw a lit palace [and reasoned], "Is it possible that this palace has no master?" [Bereishis Rabbah 39:1]. And although the root of our study is to believe in the Lord and in His Torah without [need of] proofs, and to strengthen and hold fast our traditions as our ancients of blessed memory arranged them for us — nonetheless, Chazal warned us of an honored place [for this], saying: "Be diligent to study Torah, so that you may know how to answer a heretic" [Avot 2:14]. And how pleasant and sweet, in understanding [this], are the words of Rabbi Eliezer [?]... one derives from the verse, "and you shall know the Lord your God" — and it does not say "and you shall [believe]" the Lord; and likewise it says, as it is written, "to know the Lord," and does not say "to believe" the Lord. This teaches that the way of the Holy One, blessed be He, is that, after the [form of faith] is fixed in one's heart, one should strive also to know it — so that the learner not [merely] say, "I believe that it [is so] by nature" [?]; is such a thing not good? — yet it is not reckoned to him as wisdom; rather, he must say, "I know that it [is so] by nature" [?]. Concerning this, Chazal brought [the verse of] Yirmiyahu ch. 9, "let him understand and know Me" [*Yirmiyahu* 9:23], "for in this I delight"; [?]... and He said, "and I know you by name, that you may find favor in My eyes" [cf. *Shemos* 33:12, 17].

Third: It is already known that this science is the very foundation of the work of the calendar-intercalation, as the Rambam, of blessed memory, already testified concerning it in ch. 11 of *Hilchot Kiddush HaChodesh*, and these are his words: "If these matters [seem] light in your eyes [and their ways easy], because not everyone needs them — even in this time, when [?]..."

Author's Introduction (הקדמה) — conclusion

"...[these are] far and deep matters, and they are the secret of the intercalation, which the great sages knew but would not transmit to just anyone — only to ordained and discerning scholars."

And so too the sage R. [Isaac] Israeli wrote in his book *Yesod Olam*: "The sanctification of the new moon [Aramaic: *lav milta zutarta hi* — 'is no light matter'], for you have no positive commandment in all the Torah quite like it, since upon it depend all the fixings of the festivals; and among them there is, as with Pesach, the prohibition punishable by *karet*, and this same penalty applies as with eating on Yom Kippur." End of his words.

One is therefore obligated to search and probe after this [science] with all the means our strength allows, so far as is possible. Let it not enter our hearts to say, "The tradition of our Sages suffices for us — the solution [קי"ב [?] פתרון בהונם תשל"ג [?]], and the solution [יו"ד כ"א ר"ד [?] פתרון סטכה [?]], and the signs of the intercalation [גו"ח אדז"ט [?]], and the rest of the intercalation-signs; why do we need astronomical demonstrations and matters?" [The mnemonic intercalation-tokens in this sentence are printed in abbreviated form and could not be resolved with confidence — see QA.] Let us not think so! For just as the Holy One, blessed be He, [created the world] with His knowledge, so too He commanded [that we approach] the knowledge of His Torah and His commandments [with understanding]. It has already been shown — from reason, from Scripture, and from tradition — that we are obligated to strive with all the strength of our craft to examine and expound, so far as we are able, to grasp with our intellect the reasons of things and their causes, as the author of *Chovot HaLevavot* [R. Bachya ibn Pakuda] wrote in his introduction, and also [in chapter/gate [?]].

Fourth: Our Sages of blessed memory already said, in the chapter ["Kelal Gadol," *Shabbos* 75a]: "Whoever knows how to calculate the seasons and the constellations and does not calculate — of him Scripture says, *But they do not regard the work of the Lord, nor consider the deed of His hands*" (Yeshayahu 5:12). And they said there further that it is a duty upon a person to calculate the seasons, as it is said, *For this is your wisdom and understanding in the eyes of the peoples* (Devarim 4:6) — [that is,] wisdom and understanding in the eyes of the peoples means this: the calculation of the seasons and the constellations. And Rashi explained [that the nations testify accordingly [?]]. So you have it explicitly, that our Sages [taught] that it is incumbent upon us to calculate and to know the revolution of the constellations.

Fifth: That the gentiles, seeing us [deficient] in the science [handed down [?]], revile and blaspheme us. [We must be able to answer,] so that they say, "This great nation," of whom Scripture said, *Surely a wise and understanding people is this great nation* (Devarim 4:6). For what shall we do on the day the sages of the nations address us and ask of us the reason for the order and foundation of the intercalation — and our tradition alone will not suffice for us — that we should set our hand upon our mouth and be called like a mute who does not open his mouth? This is our glory: *the glory of kings is to search out a matter* (Mishlei 25:2).

) is set above the ornament.]

The First Section (שער הראשון)

The First Section: in it will be explained a brief note concerning the four elements and the nine spheres of the heavens — namely, the seven firmaments belonging to the seven planets; the eighth firmament, which is the sphere of the constellations (*galgal ha-mazalot*); and the ninth, which is the highest sphere, whose motion is the reverse of theirs [reading of one clause here, "תנועתם הבריח," is uncertain]; and the poles of the spheres; and the location of the northern pole; together with other matters besides.

סימן א

In it will be explained that beneath the sphere of the moon there are found four elements — whether there are more above this — and an explanation of the first element.

Most of the sages agreed that beneath the sphere of the moon there are found four elements — [and it is a separate question] whether there are more above this. These are: fire (אש), air (רוח), water (מים), and earth (עפר). They have their arrangement from top to bottom, and each has its own nature; each surrounds its fellow that is beneath it on every side. Their extremities [comprise] six directions — four sides, namely right and left, front and back, and up and down; you might call these the four directions of the world, together with up and down. Thus their extremities are, as it were, filled with every corporeal thing in the world.

I shall set out for you the order of the four elements according to their place and their surroundings [and what lies] above this. We shall begin with the lowest element, which is the sphere of the earth; and after that [we shall treat] the rest, these elements that are above [it]; [and thence] we ascend heavenward and take up the nine firmaments and celestial spheres that are above.

The first element is the sphere of the earth. It is the heavy element, set lowest, the depth and abyss beneath the other elements. They said it is the center of the spheres, like a point within a circle. (The center is the middle point of a circle or sphere; all the lines going out from the center to the circumference are equal.) For [the heavens] envelop and encompass the sphere of the earth on every side [and] revolve and turn round about it at [their several] distances, as will be explained. And you must know that the sphere of the earth is round and spherical on all its extremities, and likewise all the spheres that turn round it, as will be explained further at the head of the second and third sections. You must also know that the earth as a whole is, in the view of most sages, still and at rest

at the center, and does not turn or move from its place all the days of the world — not like those who insist [otherwise] among them, [פיטוונאריו"ס [?] — a garbled name; the ancient proponents of the earth's motion, apparently Pythagoras / the Pythagoreans (?)] and his party, who lived [long before, by [?]] thousands of years, some of them recent, close to your own times [i.e., Copernicus]. [These claim] — as [the idiom] has it, that they place upon their heads "to pass an elephant through the eye of a needle" [Aramaic: *le-ayel pila be-kufa de-machta*, a proverbial impossibility] — [we are astonished [?] to demonstrate] the great height and depth and sharpness [of the argument] that the sphere of the earth revolves in a constant revolution while the spheres are at rest. Thus most of the investigators, and especially the recent sages, did not accept [this] view.

And [as for] the configuration, structure, and shape of the sphere of the earth — its length and its bounds, the seas [?] and its region, and how many parasangs its measure is; [the climes,] the [numeral [?]] ancient parts of the world and the discovery of the New World, and in addition to this a further four parts of the world; and the longitudes and latitudes of the countries, how many degrees [their inhabitants] dwell at [— all this will be treated in its place].

סימן ב

An explanation of the second element, which is water — that the earth combines with the water to form together the sphere of the earth.

The second element is water, whose nature is to surround the earth on every side, as it was from the beginning of creation, when [the earth] was entirely covered with water on all its extremities, until the third day of creation, when God, blessed be He, said, *Let the waters be gathered to one place* (Bereishis 1:9) — contrary to their nature. For given the heaviness of the earth relative to the lightness of the water, [the earth] ought properly to be always full of [i.e., submerged in] water; but the Blessed One did not create His world for chaos, but formed it to be inhabited, [so that] the earth should bring forth grass and herb and trees, grain and wine, for the benefit of man and the rest of the creatures — the birds of the heavens and the beasts and animals of the field. (Even the fish of the sea are nourished from the dry land, from the moisture of the earth that descends upon them by the flow of rain; and for the most part they are found only in places near the dry land. It is already known that the sea-creatures and the fish in the deep are all more [numerous] than [?], and that the fish [are more abundant [?]] in the rivers on land, as on a plain.) Therefore it was decreed by God, blessed be He, and it was said, *Let the waters be gathered to one place* — this alludes to the sea, the Ocean (אוקיאנו"ס [Oceanus / the ocean]), [to which] the rest

of the seas are joined, apart from a few small ones that were included [in the reckoning]; and the waters were gathered into the Ocean, as it were, as [Scripture] said, *He gathers the waters of the sea as a heap* (Tehillim 33:7). And they shall no more return to their [former] nature to cover the earth, as it is said, *He set a bound for the sea, that the waters should not pass His command* (Mishlei 8:29).

Now you must know the view of [the ancients [?]] concerning the saying *Let the waters be gathered*: that the earth should be a single sphere within [?] the water, and the water likewise spherical, [forming] as it were a world round about the sphere of the earth, [since] the earth was enveloped and covered with water on all its sides. (This is what Scripture means, *[the waters] stood above [the earth to] cover it* — implying that at first it was covered with water.) And after the saying *Let the waters be gathered*, part of the dry land was uncovered; and now the earth and the waters upon it are joined together into one sphere. The earth appears and is uncovered out of the waters — not on all its perimeter in one region, as all the ancients thought (for in their view the [greater] part of the earth's sphere is submerged in water). The matter is not so; for all the ancients are found to differ and to be mistaken in this, as will be explained before us in Section 24 [reading of the cross-reference "כב"ד כג' " is uncertain]. Rather, a portion appears and is uncovered out of the water, a little here and a little there, on every side of its extremities [around the world]; so that the earth together with the waters form in their totality one sphere, as above, suspended within the air, as will be explained.

[Section continues — the discussion of the water element from the previous page:]

of the Holy One, blessed be He. But the chief cause of it [the uncovered land] is in the fourth part of the sphere, on the northern side, where those who dwell upon it were gathered. This is the meaning of the verse in Iyov, ch. 26: *He hangs the earth upon nothing* (Iyov 26:7), as is expounded there by all the commentators — a matter of which more will be said in the third section, God willing.

סימן ג

That one should not investigate the reason and cause for the fact that the sphere of the earth hangs in the midst of the air upon nothing.

Know that some [regard it as fitting [?]] to seek a reason and cause for the earth's hanging in the air upon nothing. Some say that the heavens press upon it from every side, and by that means it remains at the center. And I further saw in the book [*[?] and the World*], in the second treatise, fourth division, chapter two, that

[the author] there elaborated at great length on the reasons for the sphere of the earth's remaining at the center, and gave many reasons there. But to my mind, and [given] the limitedness of my intellect, it seems they are all vanity and a striving after wind; therefore I did not wish to copy them and set them down in my book. In truth, investigations such as these fall to the astronomers [to weigh] — just as it is not incumbent upon us to know the cause of the fact that there is habitation round about the whole sphere of the earth in every clime, such that there are found people walking upon it whose soles are opposite our own soles, as will be explained before us at the head of the third section, in siman 25. One might wonder that this cannot be — that those people do not fall downward! But the power of the All-Capable, *who does great things beyond searching out* (Iyov 9:10), decrees things [beyond nature]; as also with Yehoshua, [at whose word] the waters of the Jordan stood still, and [the sun and moon at] Givon were [bidden] "Stand still!" All these things are outside of nature and outside of human reason, and it is not for us to investigate the reason and cause — [whether] the standing of the waters or the standing of the sun; for every revolution [is of God's ordering]. In these matters, just as it is not for us to investigate the creation of heaven and earth — concerning which it is said, *the glory of God is to conceal a matter* (Mishlei 25:2) — so [here too]. And the sage [Isaac] Israeli already wrote, in the first chapter of the second treatise of *Sefer Yesod Olam* (on the question of investigating how heaven and earth were created), an incisive parable: that just as one may not [demand] of the Creator — who is the Craftsman that fashions and directs the vessels of His works — to investigate the foundation of the gold and silver [of a vessel], and from where He created its matter, and in what proportion [He set] the elements within it; so too the astronomer may not investigate and expound the creation of heaven and earth, to know from what and from where He created them. For this investigation is of no avail, and moreover it is like a deep pit into which the mind of man's heart cannot descend to grasp it. End of his words.

סימן ד

An explanation of the third element, which is the air; and it divides into three parts.

The third element is the air. It is the wind (*ruach*) that surrounds the element of water on every side; and there is no empty place in the world that is not filled by one of the aforementioned elements. A light element is always pushed away by its heavier fellow — and this [you may observe] when you take a vessel full of air and fill it with water: the air is driven out by the water. Likewise [air displaces

earth [?]]. And although the fullness of the element of air [is not directly perceptible [?]] — witnesses do not attest to it by [touch of] cold or heat, as they attest to the two former elements [earth and water] — nevertheless it is perceived in many and various ways.

Know, moreover, that many of the ancients, and also of the moderns, said that the wind which blows upon us — which we feel at every hour — is not the elemental wind; for it cannot be that the elemental wind should always remain in its place above and never descend at all. And so too the view [expounded [?]] in the commentary on the first verse of the portion of Bereishis, folio 53c [source uncertain]. Yet I, for my part, have neither known nor heard of this [?] at all; and for this reason it appears that the mind of the discerning is not [readily] cleared of this opinion.

You must further know that in the view of some of the ancients — and the moderns all agreed — the element of air divides into three parts, one above the other, and each part surrounds its fellow, like the celestial spheres. These three parts of the air differ in [their] four qualities [of] cold [?]— [and are] not hot and dry; and the part nearer to the sun is hotter, [while the part] far from it [is colder]. On account of this, some say that the uppermost of the three parts of the air, being near the [sun], is very hot — much more so than the two parts beneath it; and by this reasoning the middle part ought to be colder than the third, lowest part. Yet they say it is not so: in their view the lowest part of the air is hotter than the first [uppermost], because [in the region where] the sun [shines [?]] — when it comes forth in its might and strikes with great force upon the sphere of the earth, the air rebounds [heat [?]], for it warms upward from the sphere of the earth and heats the part of the air nearest to it (as you will find [treated] further on, in Section [?], siman 139 [?]). By this reckoning the middle part is the coldest of all; and they said that in this middle part, as the intermediate, the [rains [?]] form and turn into snow and hail. All these things are not matters of astronomy, but rather the disputes and dialectics of the philosophers, with which we have no business at all.

סימן ה

That the [term for] air is applied in ten different senses; and the difference between *nefesh*, *ruach*, and *neshamah*.

Now know that the [various meanings] of "air" (*avir*) — which is called in the Scriptures [also] "*ruach*" and "*neshamah*" — although this is not the [proper] place [for the discussion], nevertheless, incidentally, know, according to what I have

examined closely in Scripture and labored over in books, that *ruach* is used in ten senses:

First: the kind of wind that blows upon us at every day and every hour, such as the east wind, strong [winds], the sea wind.

Second: the [element of] air — sometimes it is called *ruach*, and [sometimes] it is reckoned as "air" [*avir*] as one and the same — [as understood] everywhere among the philosophers, according to what I found in the book *[On the Heavens and] the World* [*Sefer HaShamayim veHaOlam*]: that there is a great difference between "air" and "wind," for when the air moves and blows it is called *ruach*, and when it is at rest it is called *avir*; and I found some [proof [?]] for this in the text — the Book of Iyov, ch. 41 [?].]

Third: a wind of [might / prophecy [?]], or an angel, as in *For [would that] the Lord would put His spirit [upon them]* (Bamidbar 11:29), *Take not Your holy spirit from me* (Tehillim 51:13), *[the spirit of] the Lord spoke through [me]* (II Shmuel 23:2), *He makes His angels winds* (Tehillim 104:4).

Fourth: a wind in the sense of soul / breath, as in *[the breath] of all flesh of man* [?]; and these [belong to] the [category of] parts [of the soul].

Fifth: in the sense of speech, as in *And with the breath (ruach) of his lips he shall slay the wicked* (Yeshayahu 11:4), *[…] my spirit [?]*.

Sixth: in the sense of thought, as in *A fool utters all his mind (ruach)* (Mishlei 29:11), *[the thoughts [?]]*.

Seventh: a *ruach* of will, as in *because [his spirit] moved him* — [that is,] one whose spirit prompted him [freely].

Eighth: a *ruach* of anger, as in *Be not hasty in your spirit (ruach) to be angry* (Kohelet 7:9), and *one who has no restraint over his spirit* [is like a breached city] (Mishlei 25:28).

Ninth: a *ruach* [that rests] upon the heart, as in *And the spirit of the Lord came mightily upon [Shimshon]* (Shoftim 14:6).

Tenth: the corners and winds of the world, as in *[and his kingdom] shall be divided [toward] the four winds of heaven* (Daniel 8:8 / 11:4) — [see] Daniel [?]. [Here] the winds [are meant] — I have specified them [above], and [as in] *[the four] winds [of heaven]* [Zechariah 6:5 [?]]; and the commentators explained [that the directions [?] are called] winds because [the directions draw their force [?] from them].

And the difference between *nefesh*, *ruach*, and *neshamah*: the sage [R. [?] — name uncertain] wrote, [in his commentary [?]] on the verse *[…]*, [that the *neshamah* [?] is compounded and set] like the head, and from it issue the sensations and the movements [of the limbs [?]].

The *ruach* [is in the heart] — the [seat of] the life of man; it is that which supplies the spine [?] to [the body / limbs [?]], [standing] against whatever opposes it; and it is the seat of anger. So too [Solomon], peace be upon him: *Be not hasty in your spirit to be angry* [and] *A fool utters all his mind* (Kohelet 7:9; Mishlei 29:11).

And the *nefesh* [is in the] liver, and it is that which desires to eat; and so [Scripture] wrote: *[when] your soul (nefesh) craves [to eat meat] […] as your soul desires [you shall eat] of it* (Devarim 12:20). End of his words.

סימן ו

An explanation of the fourth element, which is fire; and the property of the adhesion of the elements one to another [and their ordering [?]].

The fourth element is fire. So all the ancient investigators wrote, as one, that the element of fire surrounds the element of air and separates between the sphere of the moon and the air. You must know that the four aforementioned elements are distinguished in their nature [from] the celestial spheres, which are clear and pure like sapphires, as will be explained. Therefore each and every element, according to its nearness to the spheres, [is purer]; hence [fire] is the [purest] and most refined of all, [being] nearer to the spheres than the water and the earth; while [earth] is heavier [than the rest]. Likewise water is lighter than earth, [and each is ordered] according as [its] element is more distant from the spheres [or nearer]; and for this reason the element of earth is the heaviest of all.

And further [you must know that the nature of] each and every one of the four aforementioned elements is that it does not move from its place unless by a compeller and a mover [that removes it]; it [returns] by force to its natural place. Know, too, that the four aforementioned elements are opposed in their nature, [each to] the others: the two heavy elements, which are water and earth, are such that their natural motion is to go from above downward — so that when earth or water is [forced] upward by a compeller [such as air], the compelling element does not rest but goes and removes [it] until it settles [upon] the earth or into the water. And the two light elements, which are wind (air) and fire, are such that their natural motion is to go from below upward — as [fire] and smoke rise upward and return to their natural place. And such is the nature of the air: when

you take an [empty] vessel full of air and thrust it by force beneath the water, then when you [release] the force from it, it rises upward of itself.

Now the property of the adhesion of the four elements one to another is this: fire has no adhesion to the other elements save a firm adhesion only to air, and to nothing else. Water and earth each have two adhesions: water adheres to air and to earth, and earth adheres to water and to air. But air (*ruach*) has three adhesions, for it adheres to fire, to water, and to earth; and the adhesion of the air to fire is greater than its adhesion to water, and its adhesion [to earth] is greater than its adhesion to fire [?]. I shall not prolong [the discussion] of these matters, for they too are not matters of astronomy, but rather the words of the philosophers, with which we have no business.

סימן ז

That the moderns entirely deny [the existence of] the element of fire above.

[Reader, know well] that in all we have written above concerning the element of fire, everything is according to the view of the ancient investigators. But know that it did not escape the notice of the modern investigators — great and renowned wise men — who deny the element of fire entirely. They said: Heaven forbid that there be an element of fire above, [for] it would not be possible for us [to have] night, since from the side of the sphere of fire [its light] would illuminate the air for us every night. [And even] though this is no [real] difficulty — for the philosophers already said that there is no elemental fire with us that gives light; rather it is like [air (?)] — [they argue that] the celestial spheres, which are the [true] spheres, do not themselves give light; they [give light] only from [the] revolution [of], and from, the stars [set within them]. And just as the celestial spheres are clear and bright as sapphires, so that they neither obstruct nor interrupt the light of the stars beneath them (as [will be shown] before us, in siman 20), so too is the sphere of [fire]. In any case, we may ask of them: [consider [?]] — for the light of the celestial spheres, the stars illuminate them [i.e., the light is from the stars], as will be explained in siman 12; whereas for the element of fire we have no proof to establish [it]. Therefore they said that no element of fire is to be found above. And moreover, all that lies from the earth up to the sphere of the moon is entirely air — except that it is divided and differentiated in [its] four qualities according to its nearness to, or distance from, either the sphere of the earth or the sphere of the moon. Toward this [view] inclines the opinion of the sage R. [Ibn Rushd / Averroes (?)], [in [?]] the book *Yesod Olam* [reference numerals uncertain]. [?]]

שער א (Section One) — continued

[Conclusion of סימן ז]

[continued from the previous discussion of whether an elemental sphere of fire exists above] ...from his investigation, [holding] that the sphere of ether[?] and the fire are a single thing[?]. Thus far the quotation.[?] R. Isaac Israeli [author of *Yesod Olam*] does away with[?] an [independent] sphere of fire — explicitly, in his book *Yesod Olam*, Ma'amar 2, chapter 8, where he states, on our subject, that one of the sages likewise denied[?] a sphere of fire above; this is not mentioned[?] in the account of Creation (*Bereishis*)... [text here is badly degraded]. And he brought a proof from the verses of *Bereishis*, in several places — in the verse of the first [day], and in the verse of the luminaries[?] (*Bereishis* 1) — that there is no need to posit an element of fire, since [several words illegible]. It therefore follows that fire is not one of the [sublunar] elements, and is not a component in composite bodies; rather the sublunar world has only three [elements] — [earth (עפר)], water, and air — and for this reason they are found mixed and near one another. For just as within the belly of the earth there are springs and depths[?]... and hollows filled with much air, on account of which earthquakes sometimes occur[?] — thus far the quotation, and he elaborates further there.

סימן ח. On the number of the planets, their names, their order, and the period of their revolution.

Above the elements already mentioned — as we said, [following] the ancients[?] — there are seven celestial globes, one above the other, for the seven planets. These are: Saturn (שבתאי), Jupiter (צדק), Mars (מאדים), the Sun (חמה), Venus (נוגה), Mercury (כוכב), and the Moon (לבנה) — mnemonic **שצ״ם חנכ״ל**. This is their order and sign from the top downward; but we shall begin our exposition, in brief and modest fashion, in the reverse order, from below upward, starting with the planet nearest and closest to us, more than all the other planets [the Moon].

The first planet [the Moon], of all the seven planets, is called *Levanah* ("white") because it is white, as Radak wrote on the root לב״ן; and it is also called *Yareach* (ירח), a name derived from the renewal of the month (*chodesh*) — for the term for the span of the month is *yareach*, up to "three months' time" (*sheloshah yerachim*) [and] "a month of days" (*yerach yamim*); and because the moon renews itself each month, the [span of the] month is called by the moon's name, and *yareach* is [also] the name of the moon itself. This planet completes a full revolution in its sphere in about 27 days and some hours[?] approximately, and each renewal (molad) [comes] after 29 days, 12 hours, and 793 *chalakim* [the parts-figure on the

tile is degraded; the standard molad interval is 29d 12h 793 parts], as will be explained further in the eighth section, siman 209[?], and siman 213[?], and siman 24[?].

The second planet [Mercury] is called simply *Kokhav* ("star"), and we already find it called by [another] name[?]... — just as we find individual persons named "Adam," and many cities named [after another], as in the case of [several place-names, illegible]. So too this planet is called simply *Kokhav*. Maimonides, in the *Laws of the Foundations of the Torah* (*Hilchot Yesodei HaTorah*), wrote that whoever is [born] under it [is disposed to certain traits][?]; and I likewise found this in old books, for the matter is well known — during the hour of Mercury's rule the wise, the seekers of knowledge, are inclined to study, to write, and to reckon. This planet completes a full revolution in its sphere in about 365 days and a quarter, approximately, as will shortly be explained.

The third planet [Venus] is called *Nogah* ("radiance") because it shines and glows more than all the stars of heaven except the Sun and the Moon. And in the book of Isaiah, chapter 14, it is called [as in] "How you have fallen from heaven, *Helel ben Shachar* [Day-star, son of Dawn]" (Yeshayahu 14:12); all the commentators explained it to be the morning star, which is the planet Venus, as will be explained further in the tenth section, siman 232, [on] "*Helel ben Shachar*," etc. This planet's revolution in its sphere is about 365 days and a quarter, approximately, like the foregoing.

The fourth planet [the Sun] is *Nogah* [radiant] by its nature, and is also called *Chamah* because it melts [the world] with heat, as Radak wrote on the root חמ״ם, as will be explained further in the sixth section, siman 134. It is also called *Cheres* (חרס), meaning [the sun] — [cf.] "before the sun (*cheres*)" (Judges[?])... The revolution of this planet in its sphere, according to the reckoning of the ancient and later astronomers, is 365 days, 5 hours, and [some] minutes[?]; and according to the reckoning of our Rabbis of blessed memory — that of [Rav Ada] bar Ahava — the Sun revolves in 365 days, 5 hours, 997[?] *chalakim*, and 48[?] *regaim*, which are 76 to a *chelek*; and this returns close to a year. [See] further in the seventh section, siman 184[?] — [cross-references illegible].

The fifth planet [Mars] is called *Ma'adim* because it is red in appearance, and because it is held to govern bloodshed[?], as our Rabbis say at the end of the chapter [of tractate] Shabbos, etc. (cf. Talmud Shabbos, near 156a). This planet's revolution is in two years and a fraction.

The sixth planet [Jupiter] is called *Tzedek* ("righteousness") because it governs judges and litigants[?] and acts of charity (*tzedakah*); and some say it is so called in Hebrew for the following reason. Of it, it is said in Isaiah chapter 65, "who set a table for *Gad*" (Yeshayahu 65:11); and Radak explained, on the root גד, that it is the planet *Tzedek*, which portends every good thing, for so it is called in the Aramaic tongue[?]... meaning "good fortune" (*mazal tov*). And so [others] explained there. I have also found one who wrote that [under] the aforementioned name, they reckon for us [that] the hours of Jupiter's dominion — namely, at the onset of the eve of the second day [Monday night] and at the return of the fifth day [Thursday] — as will be explained further in the fourth section, siman 58, and siman 34[?], [on] "you shall release [what you have lent] your neighbor" — that is, on the day of Jupiter's dominion; it is Jupiter, and it is "the way of uprightness (*nechochot*)," etc. This planet completes its revolution in twelve years.

The seventh planet [Saturn] is called *Shabtai*, from the term *Shabbos* (rest) and repose, because the motion of this planet is heavier and slower than that of every [other] sphere — more than all the other planets. On this account it appeared to the ancient peoples[?] to have the power of "Shabbos"; and because its motion in its sphere is completed only after very many years — this planet completes its revolution in its sphere only every thirty years, by the nearest reckoning. This is the order of the seven planets from below upward; but most astronomy books give the order from above downward, whose mnemonic is [**שצ״ם חנכ״ל**], as above.

סימן ט. That each of the planets is set in its own distinct firmament, and why they are called "wandering stars" (*kokhvei lechet*) and "confounded ones" (*nevuchim*).

Know that the ancients decreed that each and every one of the seven planets is set in a distinct firmament — such that they held there to be[?] seven firmaments, one above another. All this because they observed that each of the seven [planets] has a known and distinct motion of its own, unlike its fellow — as [seen] also in their revolution-periods, which differ greatly: some complete a revolution in about 27 days, others in a different span, some in 12 years, some in 30 years [and so on]. (It is for this reason that they are called "wandering stars," since each one displays a distinct path — which is not the case with the stars of the eighth sphere, as will be explained shortly.) Moreover, it is impossible for a single body to move with seven [different] motions at once. Furthermore, they observed by means of their instruments that all seven planets at times draw near to, and at times recede from, the globe of the earth, by manifold measures; that sometimes

they go before the Sun and sometimes behind it; that sometimes they seem to advance forward and sometimes to move backward, and sometimes to stand still. For this reason they are called *nevuchim* ("confounded"), like a person who is lost and confounded on the road — one moment going forward, another back. On account of this, in order to explain the reason for all these appearances, it is impossible to grasp them except by assigning to each and every one of the seven planets a distinct firmament. From here all the reasons for the aforementioned appearances will be revealed, as will be explained further in the eighth section, siman 106[?].

סימן י. On the eighth sphere — called the sphere of the [fixed] stars, or the sphere of the constellations (*galgal ha-mazalot*) — and its motion.

Above these seven firmaments already mentioned, the eighth firmament is the one called the sphere of the stars, or the sphere of the constellations, in which all the remaining stars of heaven are set, from the smallest to the greatest — not one of them missing. Because the stars set in this sphere keep their distance from the globe of the earth always at a single measure, and the stars themselves keep their distance from one another always at a single, constant measure — none of them being seen [to shift] like the aforementioned [planets] — therefore they are all [placed] in a single firmament, for [the ancients] did not wish to add a firmament except [where necessary]. For this reason this sphere is called the "general" (*kelali*) sphere, the totality of the star-spheres; and it is called the sphere of the constellations for a reason to be explained further in the [sixth] section, siman 107[?].

You should further know that all the stars of the aforementioned eighth firmament are called, by the astronomers, the "fixed stars" (as opposed to[?] the "confounded stars") — because the ancient sages, over their long lifetimes, had already praised and recorded their names, saying, according to their observation, that although this sphere and its stars have no perceptible[?] motion, neither eastward nor westward — this [being due] to the fixedness of its arrangement and the slowness of the measure of its revolution — the ancients perceived in them no motion, and reckoned them to be lying still and at rest forever. And you should know that the motion and revolution of this eighth sphere is about its axis, which is the axis (center) of the earth; it too is inclined toward the east, but with a heavy motion, exceedingly slow and of very slight amount.

The time of the revolution of this sphere is, to this day, not precisely known to us — because of the slowness of its motion, no [observer] is able to fix the time of its revolution. For even if a man were to reach a hundred years — [and even] were

he "yesterday a hundred years old, as today"[?] — in all the days of his life he could not gauge, from the motion of this sphere, more than one degree of the 360 degrees of the sphere. On this account opinions about it have multiplied: according to the opinion of Ptolemy, this sphere revolves only one degree in a hundred years, of the 360 degrees of the sphere — so that, on his view, this sphere would not complete its revolution until the passing of 36,000 years. And according to the opinion of the later [Arab] astronomers, who came 640[?] years after Ptolemy, [who] made an [exact] determination and said the revolution of this sphere is one degree and a fraction (*u-miktzat*) in each hundred years — its revolution, by this reckoning, returns in 24,000 years. And there is [yet] a third opinion, as all this will be explained further at the end of the fifth section, siman 130. And you should further know that the astronomers found, in their observations, that all seven planets mentioned — besides the path each has by itself — [share], as a group, together with them, a slow motion in common with the eighth sphere, of one degree per hundred [years].

סימן יא. That all seven planets, joined together with the stars of the sphere of the constellations, all revolve by means of their spheres from west to east.

You need to know that the revolutions and motions of the seven planets by means of their spheres, joined together with the motion of the eighth sphere of which we spoke earlier — [when] we measured[?] the fixed time set for the revolution of each and every one of them — all those revolutions and motions are from west to east. This is so even though we see, day after day, the Sun and the Moon and the other stars rising from the eastern quarter and setting in the western quarter. But know that the motion of the eighth firmament with its stars mentioned — all of them revolve, each with its stars, in the time fixed for it, as above, from west to east. And because this matter is somewhat strange in the eyes of beginning students learning the science of astronomy, I saw fit — though this is not [strictly] its place — to explain the matter to them here, by [the example of] the course of the moon's revolution. For it is already known that about four hours after the molad, the moon appears at the beginning of the night in the south-western corner, a little above the circle (horizon) of the earth; and after this, on the second night, the moon appears on a higher path, farther from [where] it [was], toward the west[?]…

[continued at top of folio 13 recto] …toward the east; and so is its rule throughout the days of the month — day by day it recedes farther and farther from the place where it first appeared, in the manner of[?]… like the course of its revolution from west to east, as this matter will be explained to you more fully further in the

eighth section, siman 26. What we have said regarding the moon holds likewise for the other[?] [planets], and likewise, in the second section[?], [regarding] the confounded stars, as will be explained further in the eighth section, siman 24.

You should further know that this course from west to east is called, in the books, the "essential, natural" (*ʿatzmit ha-tivʿit*) motion or revolution — for this is their [own] course and revolution, that of the planets, by their own nature, without any external mover or compeller. But the revolutions of the Sun, the Moon, and the other planets, together with all the stars of the eighth firmament, which we see day after day rising from the eastern quarter and setting in the western quarter — the reverse of the aforementioned motion — this revolution is called the "compelled motion" (*tenuʿah makhraʿat / hekhrekhit*)[?], as will be explained shortly.

סימן יב. On the ninth sphere — called the diurnal sphere (*galgal ha-yomi*), whose motion is the reverse of the motion of the eight aforementioned spheres.

Above the eighth sphere, some of the sages decreed that there is a further, ninth sphere, which some of them call the "bare" sphere (*galgal ha-maʿarteleh*)[?], since no star at all is set in it. This is the opinion of Ptolemy and most of the ancients, who hold[?] that this sphere… its center too is the center of the earth [as it turns] from [east to west]… completing a full revolution in about 24 hours. And they say that by its great power — which the Holy One, blessed be He, implanted in it — it draws with itself all the aforementioned spheres with their stars, compelling them in its hidden course, and encompassing the world once each day. This revolution is called by the sages the "upper motion" (*ha-tenuʿah ha-ʿelyonah*), and also the "diurnal motion" (*ha-tenuʿah ha-yomit*), for a reason to be explained. The sages decreed a distinct sphere for this revolution, even though we have for it no witness — as we have for all the other aforementioned spheres, to which their stars bear witness.

[This is] because we have seen with our own eyes that all the heavens/spheres have a natural motion from west to east; and we have also seen in them an opposite motion, whereby they revolve each day from east to west. And it is impossible for a single body to move by itself with two motions at once — even in one and the same direction, and all the more so in two opposite directions. The ancients further said that one motion is from itself [its own nature], and the second is from a mover and compeller, [and so] accidental. On this account they decreed a diurnal revolution and a distinct sphere above the eight spheres, and said that it revolves and turns[?] all eight spheres as one[?], revolving the world once each day. This motion is called the "compelling, forced motion" (*tenuʿah*

makhraʿat hekhrekhit), for in their view this sphere compels and forces all eight firmaments with their stars [to conform to] this motion of its own. And you should know that from the combination of the two aforementioned motions — the voluntary (*retzoniyot*) and the forced (*hekhrekhiyot*), when they act together — depend the measure of day and night, summer and winter, the year and its seasons (*tekufot*), and other matters, which cannot come to be precisely except through the two motions acting together, as will be explained further in the [first] section, siman 140[?].

שער א (Section One) — folio 13r

סימן יג. In which it is explained how it can be conceived that a single body has two opposing courses.

To make clear and to settle the two opposing courses mentioned above is a hard matter to teach, and the sages have already offered a parable for it and made a comparison: they likened it to a man walking inside a ship [heading] from [west to east], while at the same time the ship itself is going from east to west; they also likened it to one walking upon a revolving wheel [going] from west to east. And know that this [comparison] is not quite apt — for "the case is not similar to the proof" — since we hold that the star does not move by itself, but only through the sphere as it revolves. In this, the sages of Israel concurred with the sages of the nations, as is brought in the chapter "*Mi she-hayah tamei*" [Talmud Pesachim, ch. 9]. Therefore, when the diurnal sphere turns and draws the sphere beneath it, compelling it… to the daily forced motion from east to west, how can it be conceived that at that same moment the [lower] sphere is revolving in its own voluntary motion from west to east? This is like a man whom one forces to go westward while [something] upon him compels him to go eastward — since it is impossible to go both east and west [at once]. Thus this way is difficult for the astronomers; for, after all, how can it be conceived that a single sphere or star has two contradictory motions truly at once, whether voluntary or forced? Many of the ancients and the moderns, who have exhausted their strength and cut short [their words]… all of them entered into this hidden perplexity (*mevukhah*), and we shall leave it in its concealment and difficult perplexity, holding it in reserve until we come to the corresponding siman; and there, too, another great and hidden perplexity is stirred up beyond these — we shall resolve them together.

סימן יד. How it can be conceived that a single body revolves eight bodies, one within another.

Concerning the motion of the diurnal sphere, which by its power compels all the spheres… [encompassing] the world once each day, as above — here too we have another great and hidden perplexity: that it cannot be conceived that a single sphere, by its power, should revolve eight spheres [nested] within it. For this can be accepted only regarding the motion of the sphere of the [fixed] stars alone, since it is adjacent and attached to it [the ninth]; there we have room to reason and say that the diurnal sphere turns it, holds it, and compels it perforce. But as for the other seven spheres, which it does not touch and does not reach[?]… [the notion that] it compels them is a hard matter to teach; and it does not enter our mind to say that each sphere turns the sphere beneath it and compels [it] to the daily [motion] — [namely] that the diurnal sphere compels the sphere of the stars, the sphere of the stars [compels] the sphere of Saturn, Saturn [compels] Jupiter, Jupiter Mars, and so on, all of them down to the sphere of the moon. We have grounds to inquire and say that, according to this, each sphere compels the sphere beneath it to the daily forced motion; and if so, it is likewise required that each sphere compel the sphere beneath it to its own natural, voluntary motion — and it would then be required that the sphere of Saturn compel the sphere of Jupiter to its voluntary motion, and so Jupiter [compel] Mars, and Mars the [Sun], and so on. R. Yosef Albo already raised this difficulty in his *Sefer HaIkkarim*, in chapter three of the fourth ma'amar, and there is written over it no resolution at all — he simply concluded and said that no human intellect suffices to know the truth of this matter.

But you, the reader — know well that I laid this perplexity before the wondrous astronomer who sits before our lord [the Emperor] Rudolf [II], may his glory be exalted[?], the one called **Johannes Kepler** (יוהנים קפפלירוס). He answered me and said that in truth the matter is thus: the power [resides] in the sphere, and each star's sphere compels the star beneath it [to move] in its own natural motion — as [the sphere of] Saturn [carries] Mars[?], one after another, according to their [respective] courses. Saturn moves about [8?] degrees[?]… Jupiter moves two degrees each month… [through] the twelve constellations. Let us now suppose[?] that a sphere revolves in month [8?] up to the point [ג][?] of the circle, drawing with itself[?]… Jupiter, which in that month… [each] sphere draws the sphere beneath it, and its own natural motion, up to point [ג][?]… so [too] the sphere of Mars, which in that month…

Diagram. A set of nested concentric semicircular arcs (flat side downward), drawn one within another, illustrating the nested celestial spheres — the visual counterpart of Kepler's ship-man-fly analogy, in which each outer sphere carries

within it the sphere beneath. Points are labeled along the base diameter, left to right:

- א (base, left / outermost): outer sphere
- ב (base): the sphere next within
- ג (base): the sphere next within
- ד (base, right)[?]: innermost sphere — label uncertain …[Mars] revolves by reason of the motion of Saturn's sphere, by reason of the motion of Jupiter's sphere, and by reason of its own motion — up to point ג of the circle. So the star Mars reaches point ג through three causes: the motion of Saturn's sphere, the motion of Jupiter's sphere, and its own motion — besides the fourth cause, [the motion] of the sphere of the constellations [and the ninth sphere]. And he [Kepler] said: Behold, one ship crosses the river from [west] to east; and while it is crossing, a man walks from [the stern] of the ship to its bow — likewise from west to east; and a fly walks upon the head of that man, from the [back] of his crown [to the front] — likewise from west to east. In such fashion, whereas [the fly] was at first at the rear, at the [bank] of the river, over against [X], it is now foremost, at the river-bank, [displaced] purely eastward — and this by [the combined] cause of the ship's motion, the man's motion, [and the fly's own motion]. Just as the fly [is carried by all three], so the voluntary motion of the sphere of [the Moon][?] has one [proper] cause — the cause of its own motion — [together with] the motion of Saturn['s sphere]… and the motion of Jupiter, for three causes… and the motion of the sphere of [the Moon], for eight causes. According to this, the great perplexity is well settled, and it poses no difficulty for us at all.

סימן טו. In which is explained a resolution to the two aforementioned perplexities.

And you, the reader — know well that in my humble opinion it appears [that] the two perplexities mentioned above [may be resolved] as one. How can it be conceived that a single body [has two opposing motions]? — [namely] the first [perplexity], the two opposing courses, and the second, how a single body revolves eight bodies one within another. This too can be settled in another way, in the true way, and I say: each and every one of the eight spheres is itself divided, within, into three globes (*kadurim*), one within another, as [explained] further in the seventh section, siman 187[?]; for all the sages, ancient and modern, agreed that within each and every sphere — as within the sphere of the Sun, for example — there is set another sphere, called the sphere [of…]. …[Thus]

all eight spheres are all conjoined and attached together as one whole, such that when [the outermost] revolves, overpowering them, they all revolve together; and so each and every sphere carries the [sphere] within it in its own natural motion — like the likeness of an embryo in its mother's womb — as above. By all this, everything works out well, and we may now say that what the author of *Sefer HaIkkarim* wrote — that the whole human intellect cannot attain this matter — [is resolved].

And from the sum of the aforementioned matters, one should note and say [the following]: as for what the astronomers wrote — that the diurnal sphere, by the great power God (may He be blessed) implanted in it, draws and compels the eight spheres along with itself, revolving the earth once each day — according to our explanation above there is no need for this, since [in our account] both the eastward motion and the westward motion would [alike] be voluntary and natural. And perhaps it is on account of all this that some deny [the existence of] the diurnal sphere, as will be explained shortly, in siman 18, God willing.

סימן טז. A further resolution to the two aforementioned perplexities.

And we shall not conceal from the reader's eye that, according to the opinion of the great investigator **Tycho Brahe** (טיכא ברהי)[?], the stars, in his view, [are set] in a fixed sphere, and [it is rather] a returning star[?], as will be explained further…

[The exposition of Tycho's view continues into the following pages.]

שער א (Section 1) — continued

[Conclusion of] סימן טז (Siman 16) — Tycho Brahe's resolution of the two perplexities

According to his [Tycho Brahe's] view — see below in siman (25) כ"ה — we have no cause to wonder at the two motions mentioned just above, nor at the very existence of the opposing motions. This is easily grasped, for the analogy of a human being suffices: a man walking about on a ship, or on the turning wheel of a wagon. On this understanding one may say that the sphere's course is one thing and the star's course another — for the spheres as a whole carry [the stars] each day from east to west, while the star itself revolves slowly upon the back of its sphere from west to east.

From this it also follows that the second perplexity — "this [motion] within this [motion]" — falls away at its very root. For since the star is fixed [in its sphere],

we need not say that each sphere revolves and grips the sphere beneath it and overrides [it with] the diurnal motion, as [explained] above. It emerges, then, that both the eastward circular motion and the westward motion are voluntary [natural], and no ninth sphere is needed at all.

סימן יז (Siman 17) — Why the ninth sphere is called "the diurnal sphere," and that it has but a single motion

The ninth sphere of which we have spoken is called by the sages "the diurnal sphere" (*galgal ha-yomi*), because it is this sphere that brings the day [?] to the world: by its revolution the sun rises over the earth and gives light to the day. Or [it is so called] because through the motion of this sphere the natural days and their times come to be; for through its motion a complete [day] is delineated — for one half of its revolution, that is, twelve seasonal hours above the earth, is the time of day, and the other half of its revolution, likewise twelve seasonal hours beneath the earth, is the time of night. These two periods together the sages call a "natural day" (in Latin: *dies naturalis* [דיע"ם נטוראלי"ם]). This is the sense of the verse "and there was evening and there was morning, one day" (Bereishis 1:5) — meaning that the evening and the morning, when joined together, are called one day. For were it not for the motion of this sphere, the world would always [have?] one [region?] in [continuous] day and one in [continuous] night in every clime [אקלים, clime], as will be explained below in Section 6, siman (134) קל"ד [and] (140 [?]) ק"ם.

And know that the motion of the diurnal sphere, which revolves from east to west, is its own essential motion; this sphere has no other motion besides it. This is unlike the other spheres, each of which, together with its star, has four or five motions, as will be explained below in Section 7 [and Section 8 (?)], siman (88) פ"ח and siman (208) ר"ח.

סימן יח (Siman 18) — Setting out the differing opinions concerning the existence of the ninth sphere

Know that concerning the existence of the ninth sphere there are differing opinions and disputes, and they are three schools.

The first school say that there is a driving sphere which by its power [drives] all eight spheres and encircles the globe of the world in twenty-four hours, from east to west, as was explained above in siman (16) ט"ז.

The second school also concede a ninth sphere, for a reason to be explained; but they say that it is not a body like the other spheres — which are called by the

sages "the fifth body" (*ha-geshem ha-chamishi*, the quintessence) and which carry [?] the stars like a thread. Rather [the ninth] is a separate [intellect] or an angel that moves the sphere, [and] is not corporeal; and this is likewise implied by the language of Rambam [Maimonides].

ראב"ע [abbreviation uncertain [?]]: as is demonstrated in chapter three, treatise four [?] of *Sefer HaIkkarim* [of Yosef Albo], which wrote that there is nothing corporeal above the sphere of the [fixed] stars — meaning that he concedes there is a mover above them, only that it is not a body like the other perceptible spheres [carrying the stars] like a thread, but rather a separate intellectual essence.

The third school deny the ninth sphere and say that there is nothing above the sphere of the stars — no sphere above it "to where the eye can no longer see" — and that you must not add anything above the sphere of the stars, whether body or non-body, because in their view the sphere of the stars carries with it all the spheres within it from east to west, once each day. This is the opinion of Ibn Rushd [אבן טח"ד — read as אבן רשד / Averroes [?]], and likewise the opinion of the wondrous sage R. Avraham bar Ḥiyya per what he wrote in his book *Tzurat HaAretz* (The Form of the Earth), gate two [?]; and likewise the opinion of Ralbag [Gersonides] per what he wrote in his book *Milchamot HaShem* (The Wars of the Lord), chapter (24) כ"ד of treatise 2 — that is, that one need not posit a starless moving sphere, for [its motion] would be in vain and to no purpose, since it serves no benefit, and among natural things there is nothing purposeless, as [he wrote?] concerning the honored heavenly [bodies]. It was for this reason that he decreed and stated that there is no sphere at all above the sphere of the stars.

In any case, know that even if it be proven that there is no sphere above the sphere of the stars, I say to you that the reversed eastward [/westward] motion — whether it be from one of the causes [related to] the stars, as [treated] nearby in simanim (15) ט"ו ,(14) י"ד, [and י"ד ט"ו], or from some other cause and beyond it — ought by right to be called, in all the books, "the upper motion" or "the diurnal motion," and it is [rightly] so termed [?]. And see below at the end of siman 13) י"ג ([?].

And it seems right to add: even if it be granted as certain that there is no sphere at all above the sphere of the stars, nonetheless, for many purposes — such as [reckoning] the fixed constellations and the precessing [ones], as [treated] below in Section 5, siman ([?] 106) ק"ו, and for other purposes besides these — we need to picture in our minds, in order to explain [it] to students, [something] as though it were a ninth sphere, even though it is clearly known to us that this is not so.

Diagram. A large concentric-circle cosmological figure occupying most of the page, captioned **"צורת ארבע יסודות ותשעה גלגלים הנזכרים"** ("Figure of the four elements and the nine spheres mentioned"). Reading from the outermost ring inward, each ring is labeled and separated by rows of small six-pointed star marks (✻):

- Outermost ring: **גלגל היומי** (the diurnal sphere), labeled at the top.
- Next ring: the zodiacal band (the sphere of the fixed stars), divided into boxed constellation-cells with star symbols. Legibly readable cells: **טלה** (Aries, at top), **שור** (Taurus), **דגים** (Pisces), **דלי** (Aquarius), **גדי** (Capricorn), **אריה** (Leo), **בתולה** (Virgo), **מאזנים** (Libra). The remaining cells (Gemini/תאומים, Cancer/סרטן, Scorpio/עקרב, Sagittarius/קשת) are not clearly legible on this scan [?].
- **שבתאי** (Saturn) ✻
- **צדק** (Jupiter) ✻
- **מאדים** (Mars) ✻
- **חמה** (the Sun) ✻
- **נוגה** (Venus) ✻
- **כוכב** (Mercury) ✻
- **לבנה** (the Moon)
- Inner (sublunar) region: **רוח** (air) and **אש** (fire) are legible; the innermost small circle (the earth) and any water-ring label are not clearly legible [?].

(more than two labels flagged [?]: several zodiac cells and the innermost element rings). **further review (R7,.md):** independent cold read confirms the 9 sphere rings + fire/air + 6 zodiac cells (טלה/שור/דגים/דלי/מאזנים/בתולה); it could NOT confirm אריה/גדי (downgrade those to [?]), reads תאומים/סרטן/עקרב/קשת as probable-[?], and leaves water/earth-center at the scan floor.

סימן יט (Siman 19) — A brief explanation of the adjacent figure

In the adjacent figure above is depicted [?] the three parts of the world [שלשה חלקי העולם [?]] — namely [the elemental world?], the [?], and the [?] [the specific terms are degraded here [?]]; their combination [connection] will be explained below in siman (71) ע"א. And its cause [?] [degraded]... like [?] the globe of the earth [in the figure]; here air [is shown] in the form of a sphere, one of them [the elements], as we explained all of this above in siman (20) כ'.

Above the corporeal elements [and the ?-ial ones] is the sphere of the seven wandering stars [planets], and above them [?] the sphere of the [fixed] stars...

[and above them] the diurnal sphere. Also there are marked in the figure twelve constellations [שנים עשר מזלות], and they are [there] in two respects [?].

In the upper sphere [the diurnal sphere], although there is no star set within it at all, nonetheless there are marked upon it, in a circle, all twelve constellations as if they were fixed there; and these are called "the fixed constellations," which never change or alter or shift from their position for all the days of the world. And the second respect [is] the constellations marked in the sphere of the [fixed] stars, where the constellation truly [resides] in [its place] [?], except that they are, by reason of the heavy [slow] motion — the second [motion?] of the sphere of the constellations, as above in siman (14) י"ד and below in Section 5, siman (110) ק"י ([?] — the precessing constellations [ha-mazalot ha-mitmotetim], and they will change and alter their position over a very great distance across time. In our time, in [the band of] the fixed constellations, the head of the sign of Aries is marked; opposite it, below, in the sphere of the constellations, it would be fitting that the sign of Aries likewise be there; but on account of the precession [התמוטטות] there is now found there the head of the sign of Pisces — as will be explained well below in siman [?].

שער א (Section 1) — folio (15) טו

סימן כ (Siman 20) — That the globes of the spheres are like the layers of onions, with no void between them, and are clear as sapphires

Since it is impossible to depict a globe upon a [flat] surface properly, therefore [the artist] depicts [it] as sliced [in cross-section], cut open on the near side, so that [?] one sees, in the cross-section, only the likeness of the spheres, one within another; so too you can [envision] all the spheres, transparent [?], one above the other on a smooth surface [?]... all [being] spheres [?] and complete globes, like the complete layers of onions.

And know further that all the spheres of the firmament are contiguous and adjoined, one within the other, like the layers of onions, and there is no empty place or void between them at all. The sages have already agreed on this, and the dispute of the philosopher[s] in such a matter, and at length [?], to demonstrate to [His] creatures [?]... And since it is an established premise that there is no void at all in the world, it is thereby explained to you that every sphere touches and adjoins, by its convex [outer surface], the sphere above it, and by its concave [inner surface] the sphere below it — down to the concavity of the sphere of the Moon, which touches the convexity of the sphere of fire, [that of] fire, for one who concedes its existence, or [the sphere of] air [?].

And [I] make known to you [further], so you may understand, that the substance of every sphere of the firmament is pure and clear as crystal and sapphire; and for this reason all seven firmaments are translucent [?] and do not interrupt or block the [boundary and] shining light of the stars of the eighth sphere from giving us light upon the earth. And just as [written?] concerning the spheres [?]... [that] they [?] are translucent and do not block from us the light [?] — so too all seven firmaments are translucent and do not block from us the light of the stars of the eighth sphere.

סימן כא (Siman 21) — The axis and pole of the sphere, and the two pivots and poles of the world

Know that [when] one draws [?] a line encircling [passing through] the center of the globe or sphere, passing through the center and emerging to the other side — it is called a *beriach* (a bar/axis), because it "bars" [reaches] from end to end, as [in] the tradition. And the sages of [the science] [?] called it *quṭr* [קוט"ר; Arabic: قطر, "diameter"], and it is an Arabic word. Some say [?] it is the *beriach* mentioned in Iyov (Job) [26:13 (?)] and in Yeshayahu (Isaiah) [27:1 (?)], as is written in the *[Sefer Ha-]Shorashim* (Roots) [of Radak?], [in his commentary on Bereishis?] the first [?], treatise two [?]; and see below in [Section] 8, siman) קפ"ט (189.

The two points at the ends of the bar are the pivots [tzirei] of the world: the one is the northern pivot and the other the southern pivot, and the researchers call it the "northern pole" (*quṭb*) and the "southern pole." Upon these two pivots all nine spheres, all of them, revolve each and every day from east to west; and in [all] nine spheres not even a single point remains at rest and still in place — only the two points of the two pivots alone remain always in their place.

To explain it to students: imagine that you take a sharpened square [rod], and drive or thrust it through a ball or an apple from side to side, and set the two ends of the sharpened [rod] upon a vessel, and rotate the ball or apple [continuously — for it seems to you that the two ends turn and revolve in place, in the point of a needle; yet withal, the two ends of the pole do not shift or waver, but always remain fixed in their place].

סימן כב (Siman 22) — That the northern pivot and likewise the aforementioned southern one, they alone are the pivots of the ninth sphere

Know that the two pivots, or poles, that we mentioned are the pivots of the world, upon which revolves the sphere of the upper motion — that is, the diurnal sphere — in every case; for all nine firmaments revolve each and every day by means of the two aforementioned pivots. But the particular [?] motions of the sphere of the Sun and the Moon, together with the other spheres of the five wandering stars [planets], and likewise the motions of the sphere of the [fixed] stars — whose primary [?] course in the world goes from [east?] to east [?], as above — have two other, small poles, somewhat distant from the aforementioned poles of the world, near twenty-four degrees [כ"ד מעלות], as will be explained below in Section 2, siman (34) ל"ד.

It is thereby explained to you that in many spheres no point at all will be found that is at rest and still with respect to their own two pivots, for they too are moved by the cause of the diurnal sphere, and they make one circle, revolving [with?] the world, once each day, as will be explained in siman ([?] 37) ל"ז.

And know that all this holds only [?] according to the view of the sages who concede a ninth sphere. But as for the words of those who deny a ninth sphere and say that there is nothing above the sphere of the stars, it appears that in their view the two pivots of the world are themselves also in the sphere of the constellations. Accordingly, the sphere of the stars would have four pivots: two pivots of the [proper] motions upon which [?] the [enclosing] spheres each revolve, each in its own time, from west to east; and the two pivots of the world, upon which they all, as one, revolve the globe of the earth once each day. And should it trouble you — is it possible that a single body should revolve in two opposing motions? — we already explained above in siman (14) י"ד and (15) ט"ו that it does turn [so], according to the grasp of our intellect.

סימן כג (Siman 23) — That even those who deny a ninth sphere, it is fitting for them to say "the diurnal sphere" or "the upper motion"

A small note, to be kept before your eyes: wherever you find, in this book of ours or in another, the matter of "the upper motion," or "the diurnal sphere," or "the sphere of the [outer] part" [?] — let it not trouble you, and let it not perplex you, what this will mean for the words of those who deny the ninth firmament. For from what we explained above this is settled, on two grounds. First: a star may [move] by its own essential [natural] motion without needing any [driving]

sphere; it simply revolves upon the back of the sphere, like a star moving on the wheel-sphere. And second: [because] each sphere is set within [?] another sphere, and by [being pressed together] all the spheres are joined and fixed [?] together as one mass, so that by the revolution of one of them all of them necessarily revolve, as above in siman (14) י"ד and (15) ט"ו. And [should] it arise in your mind [that this passage concerns] a ninth sphere or [that it] does not literally [exist] —

therefore, whatever your intent in this passage, whether [it be] the sphere of the upper motion or the [claim] that it does not [exist] — hence know that each [term] [?], whether the matter of "the sphere of the upper motion" or the matter of "the diurnal sphere" or "the sphere of the [outer] part," you can interpret it [?]... as [it holds for] those who concede a ninth sphere, so too for the view of those who deny it [?]. And [one] may say that the [inner surface/belly] of each and every one of the eight firmaments should be called "the sphere of the upper part," since the [inner surface] of each upper sphere is above the sphere beneath it; and likewise it is right that [it] be called "the diurnal sphere" or "the circular motion." And see below in siman [?].

שער א (Section 1) — folio טו verso

סימן כד (Siman 24) — That every star makes, each [day], one circle around one of the pivots

From the general principles that we mentioned, it is explained to you [?] that every star of the firmament makes, each day, by its course, one circle around one of the [two] pivots — namely, around one of the two poles of the world. Now the stars [near a pole are close together, those far apart make larger circles?]... [these] are like the spheres of the stars that revolve [?]... the spheres of the stars, or the coils [gelilei] of the revolution about the sphere [?].

They have no mean [?]; some of them are large, some small; and some of the stars make a large circle and some of them make a small circle — and this is according to their nearness to, and distance from, the pivots. For every star that is near the pivot, its course will be smaller in extent [?], and a star far from the pivot [?] — [one] of them makes a large circle; and this is according to their nearness [and distance] from the pivots. [Two?] stars, or more, standing upon [?] one line at [such] a distance from [?] the pivots, or [all] of them, encircle [the pole] as a single coil [?].

סימן כה (Siman 25) — Whether the star is fixed [in its sphere], or the sphere is fixed and the star moves

Most of the sages, the ancients and the moderns, decreed and stated [?] that, by [all] the [proper] reasons, [none] of the seven wandering stars [planets] [?] — no one of the seven wandering stars [?] has, nor adds [?], any motion of its own at all. Rather each of them is fixed and embedded in the hollow of the thickness of its sphere, and the rising and setting and shining of the stars, and their inclination to the north and to the south, is nothing but [a result] of the motions of the star-spheres that carry them — like people sitting in a ship, or [?] fixed in a wheel-sphere, in the manner that the star is fixed and [the sphere?] turns [?] — not according to the one who says that the sphere is fixed and the star moves. And here [is] a dispute of the Jewish sages against the sages of the [gentile] nations [regarding] astronomy [?], each according to his view [?], which was [set down] plainly [?].

But know that the great, wondrous investigator into the science of the stars, unique in his generation — that is [?], [among] the sages dwelling before his lord the Emperor Rudolf [רודלפו"ס; Rudolf II], the well-known [?] lord **Tycho Brahe** [טיח"א ברא"הי] — said [?]: "The external [gentile] sages did well to concede to the astronomers concerning the matter [of ?]..." his [dispute?] with the Jewish sages, in saying that the stars turn [move] [?] like a matter [?]... [by their] essential [motions] without the compulsion of the motions of the spheres, but rather like circles [?]... and they wish [?], like the body of a bird in the air, and [?] its wings [?]. And he wrote a book [?] on this... [demonstrating] by his signs and his proofs [?] that some of the stars revolve [?] within a fixed sphere [?] and pass over the [surface of?] a circle — [namely] the path of the sun, etc.

[continued, second column:]...[for it was such that] there was none like him until [?]... And likewise [?] because that wondrous [sage] **Kepler** [קעפליר"ס], as one saying: since it appears to us, for [certain] reasons, that some of the stars sometimes shift and circle [?] also in other figures outside their accustomed place... toward the northern side of the [path/orbit], and likewise toward the southern side, so that it is impossible to sustain [?]... and this [is] the fundamental [difficulty] of the courses of the revolving stars — unless we say that the stars sometimes stray [swim] in the firmament like a branch [?] growing [?] in the air, [floating] as [in] the air.

And this too I saw fit to make known to you: that I asked [?], concerning the words of the sage Don Isaac [Abarbanel?; דון יצחק חבר/אברבנאל [?]] in his commentary on the [portion of] Bereishis, on the verse "And God made the two

great luminaries" (Bereishis 1:16) — [which touches upon] philosophy; for he wrote that the luminaries were not [set as] parts of the spheres, nor fixed within them, but rather that the stars travel in the air between the heavens and the earth, and that the spheres are powers [only] and do not themselves move [?]. And he wrote there further that it is not fitting to decide firmly [in accordance with] what our Sages, of blessed memory, said — that the sphere is fixed and the star moves — for it may be a mistaken [?] view, [and] the matter is at the least in doubt; [and yet] they took it [?]. Nevertheless, there is a great testimony in the words of our Rabbis, of blessed memory, in [Bereishis], and in the words concerning the luminaries. And on this very point [it is] said there [in the name of] R. Shimon bar Yochai: "We do not know whether they [the luminaries] fly in the air, or float in the firmament, or travel in their [ordinary] way — the matter is very difficult, and it is impossible for creatures to attain [certainty] concerning it" (Bereishis Rabbah 6:8). Thus far [his words].

סימן כו (Siman 26) — To find, in the eighth firmament, the point corresponding to the northern pivot that is in the ninth sphere

Know, my blessed friend [?] — for we too dwell and reside with you toward the northern side of the world, as was explained above at the head of this Section, and as will be further explained below in Section 3 — that the northern pole, or pivot, which is high [?] above us, rises up over against [us] [?]... in the [region of the] earth, higher and higher; whereas the southern pivot is hidden and concealed from us, as will be explained.

And since knowing the location of the height of the northern pivot is of great need to us — for knowing the whole face [?] of the heavens, and for knowing all the settled [regions] and boundaries of the entire globe of the earth — you have nothing more necessary to study, in this science, than it. Therefore, [although] the northern [?] pole is itself not visible within the circle of the [seeing] eye, one can find the place of the northern pivot by an easy way, [that seems?] not lacking [in] reckoning or measure at all. It is already known to the [discerning], to most of our wise men, [that there are] the great, shining stars toward our north that never set for us — those stars whose configuration [?] is designated by the letters א"ב ג"ד [A, B, C, D] and so on, which the astronomers call **"the Great Bear"** (דוב הגדול; Ursa Major), and which the multitude call "the Wagon" (העגלה); and the other, smaller ones that are near us [Ursa Minor], which are called for you by the [name] [?]...

שער א (First Section) — continued

סימן כו (continued)

[continued from the previous page] …Now take, in your mind's eye, two stars — star ב and star ג of the figure before you — and draw from these two stars two lines running steadily upward [?]. You need concern yourself only with these two lines, until they bring you to meet two further stars; join those as well, and continue higher up [?]. In the same way you will arrive at four stars set out in a square, like this. [A small square of four star-marks (⁂) is printed here.]

Higher still there are three more stars close by [?], and when you combine them all you find seven stars in all — these form the "Little Wagon" (עגלה קטנה), shaped like the [Great] Wagon [?], and it is for this reason that the astronomers call it the **Little Bear** (דוב הקטן). The outermost star of the Little Bear is this one here: a star small in magnitude yet bright and clear, and it is called the **Pole Star** [כוכב הקוטב, Polaris] [?], since it [lies?] toward the [north?] [?]. Because it is set very close to the pivot [?], astronomers use it to align [instruments] toward the point they need, over against their dwelling-place [?]. Even so, you should know that this star is not the true pivot itself [?].

You should also know that the aforementioned stars — [the outer star of] the Little Bear and, likewise, the Great Bear and the other [circumpolar] stars — never set for us who dwell in the north [?], but circle the pivot without setting, sometimes appearing above it and sometimes below it. (Their nature will be explained to you at the end of the third Section [שער ג].) [reading of this passage is degraded; several clauses [?]]

סימן כז — The figures of the Great Bear and the Little Bear, and that the aforementioned pivot is only a pivot *resembling* the true pivot

You should know that the Little Bear — and likewise the Great Bear and the other [circumpolar constellations] — [remain visible], [each of them] standing above [the horizon] [?]. I have marked out for you the position of the head-point [nose?] of the pivot [?], as it appears in the figure, so that from here on you may find the location of the pivot-point [nekudat ha-tzir], measured and verified as it stands above the earth's horizon at every time and in every place, between one setting and another [?].

Diagram. A star-chart of the circumpolar region occupying the upper part of the left-hand column, printed as a field of six-pointed star-marks (✻) with lettered points and a woven legend. Two headings run across the top of the chart.

- Heading (right): כוכבי שמים ("Stars of the heavens")
- Heading (left): כוכב המזלות ("Star[s] of the constellations")
- ציר — "Pivot" (the [apparent] celestial pole), marked among the stars near the top
- דוב הגדול — "Ursa Major / the Great Wagon," lower group, with a point lettered ו
- דוב הקטן — "Ursa Minor / the Little Wagon," with a point lettered ה
- Additional lettered star-points: א, ב, ג
- Woven legend (partly legible): "the stars near [the pivot] … never set … forever, as will be explained further on in the second Section, siman [ק"ט ?109] … sometimes they are [above the pivot] and sometimes below" [legend heavily degraded — [?]]

[More than two labels are uncertain]

And you should further know that, according to what we already established — that the pivot of the world lies in the uppermost sphere [?] — the pivot-point that I have marked for you here, in the sphere of the fixed stars, is not the pivot itself. Rather it is called the **"resembling pivot"** (ציר הדומה), because it exactly resembles [lies directly opposite] the true pivot [?]. (This will be explained further on in the fifth Section, siman [?138] קל"ח [?].) Fix this in your memory and keep your eyes upon it, for you will need it further on. Know, too, that the times noted for [determining] the position of the pivot hold precisely only for our own era [?]; but with the passage of many years and long stretches of time the markers will shift, on account of the motion of the sphere of the heavens, as will be explained [at the end of the fifth Section, siman קל"ח] [?].

סימן כח — Demonstrations that the heavens are spherical, and that no shape is like the spherical shape

All the sages, ancient and modern, agreed that the spheres are all spherical, and they offered demonstrations and proofs for this. Foremost among them is what they found: that all the stars of the firmament [are seen], in every place [?], at an equal distance from the center of the earth. This follows from the fact that all the lines [drawn] to the circumference of a circle from its center are equal to one another. Therefore, if it should enter your mind that the sphere of the heavens

were square, or oblong, or lens-shaped, or [drawn out] to a corner, or shaped like a lentil [?], then the lines would not all be equal, and one star would be farther from us than another [?].

Moreover, they observed that in all places of the world the [apparent] breadth [size] of each individual star among the stars of the eighth sphere is always of one and the same measure [?]; whereas, were the firmament a flat surface, a single star would appear larger in a place nearer to it in its center than from another, more distant place [?]. And as the investigators established regarding the sphericity of the earth: they said it is a natural thing that the [most perfect] object has priority over [any] possible [imperfect] one, and that the sphere retains its form at all times while it is a sphere; it is impossible to add to it or subtract from it [without destroying it] [?] — for when you subtract a little from it, or add a little to it, it is no longer called a sphere, whereas a simple line can be added to or subtracted from and still remain a simple line [?].

It is already known that all shapes that exist are either simple or [composite] [?] — or [equilateral] [?] or composite — for all the other shapes branch out from [the basic] three [?]. Now the spherical shape has a [natural superiority?] over all other shapes [?]: for a circular [or spherical] figure is enclosed by a single line alone, whereas the others require many lines [?]; and in every genus, the one [the unity] is by nature prior to the many. Third: all the philosophers hold it as an established premise that there is no [void] place outside the world [?]. Now suppose it should enter your mind [that the heavens were not spherical]…

Diagram. A triangle with a circle inscribed within it, at the foot of the page. The three vertices are lettered:

- א — top vertex
- ב — lower-left vertex
- ג — lower-right vertex

This illustrates the argument that, were the heavens shaped as a triangle א־ב־ג rather than a sphere, everything lying in the corners *outside* the inscribed circle would necessarily be "outside the world" — which is impossible.

[Suppose] the heavens were not spherical, but (let us posit) the triangular shape א־ב־ג [?]. It would follow from this that there is a place outside the world — namely, that everything falling outside the triangle א־ב־ג is "outside the world" [?]. And when [the sphere revolves within it], the three corners or angles of the triangle א־ב־ג [that project beyond the inner circle would be set in motion, and in their motion would sweep the outer circle] [?], and would leave empty space

[within the world and a place outside it] [?] — which is impossible according to the philosophers. The same reasoning applies to all shapes that are not spherical or circular.

Furthermore, the sages wrote [proofs] for the sphericity of the heavens and the earth, since there is no shape [more fitting] [?] — for the circular motion is better suited to revolving than any other configuration [?]. [This passage in the left-hand column is degraded — several clauses [?].]

[Concluding σ28, at the top of the left column:] ...[which is] sound, fitting, and [worthy of transmission] to the wise [?], [namely] the statement that the circular or spherical shape is more capacious than all shapes, as will be explained in the siman next to this one. Said the author [?]: "How manifold are Your works, O Lord; in wisdom You made [them all]" (Tehillim 104:24). The true demonstrations concerning the sphericity of the heavens — the rest will be explained to you in the writing of the third Section [?].

סימן כט — That the circular shape is more capacious than all shapes

The demonstration. Among all shapes there is found no shape more capacious than the circular shape — although this matter is geometrical, and this is not the proper place to lay it all out [?]. I saw fit only to enlighten the reader's eye [?], since the ancient sages already illuminated this matter with [geometric proof] [?]. And here it is:

Take a line A of length **22** cubits [כ"ב], and make from it a circle; its diameter will then be **7** cubits [ז]. The area (תשבורת) of this circle is known to us from the product of half its diameter times half its circumference: for half its diameter is **3½** cubits [ג' וחצי], and half its circumference is **11** cubits [printed glyph reads י"ח/י"א — [?]; arithmetic requires 11]. When we multiply 3½ by 11, we get **38½** [printed glyph uncertain — [?]; = the area]. Now if we make from [that same line of 22 cubits] a **square**, each side will be **5½** cubits [printed glyph reads כ' — [?]; a perimeter of 22 gives 5½], and its area — known from the product of the two sides of the square, one by the other, that is 5½ times 5½ — comes to **30¼** [שלשים ורביע]. Thus you see that in every case the circular shape holds more than the square shape by **8¼** cubits [שמונה ורביע; and indeed 38½ − 30¼ = 8¼]. This is clear and simple to those who know the science of mensuration and measurement. [End of siman.]

Diagram. In the left-hand column, a set of nested concentric circles (a schematic of the nested spheres / a circle drawn with many rings). No lettered labels are printed on it.

Diagram. Directly below the concentric circles, a wedge/triangular figure built up of stacked horizontal rules (a triangle rendered as a graded stack of lines), evidently paired with the mensuration demonstration above. No lettered labels are printed on it.

סימן ל — That the sphere of the constellations (the ecliptic) is divided into 360 parts along the length of the world, and likewise across its breadth

All the ancient sages agreed that every line encircling the middle of the sphere of the constellations — and likewise all the other great circles that pass [through the whole earth] [?] — each one of them [is divided] into three hundred and sixty parts, and they called them **degrees** (מעלות). I will designate [?] this division in a brief manner, as will be explained further on in the second Section, siman [קל"ח [?138 [?]. The astronomers also explained that they divided it precisely into this number [360] because it is subject to many divisions — into halves, and thirds [?], … quarters [?], fifths, sixths, eighths, ninths, tenths, twelfths, fifteenths, eighteenths, twentieths, twenty-fourths, thirtieths [?], and others; and further, because this number is close to the number of days in the year, for on each and every day [the sphere] revolves [?] in its harmonious course [beneath?] the sphere of the constellations by nearly one degree, a little less, as will be explained further on in the seventh Section, siman [?165] קס"ה [?].

As for the point from which the reckoning of the 360 degrees on the circle of the constellations begins — the ancient sages agreed to take [its start] [?], and set as the head and beginning of the reckoning the point they called the **first point of Aries** (נקודת מזל טלה), as will be explained. [At the very] beginning of Aries the line begins, upon which the 360 degrees are inscribed [?]; it proceeds and circles by way of Taurus, [Aries,] Taurus, Gemini, Cancer, Leo, and so on [?], encompassing all the curvature of the firmament until it returns to the point [from] which it began; and thereby the 360 degrees are completed, as will be explained further on. The path of this revolution is called the "line of the length of the firmament" [?].

Likewise the circle that revolves above the center of the earth, from north to south [the meridian], also holds 360 degrees. In any case, know that all the circles

revolving between north and south are each divided into four quarters, ninety degrees falling to each quarter; the lines of these quarters are each called "the breadth of the firmament," as will be explained further on in siman [?34] ל"ד and siman [?60] ס' [?].

You should further know that the astronomers agreed to divide each and every degree of the 360 degrees of the sphere still further, each into sixty parts, which are called **minutes** [דקים] or **seconds** [שניים] [?]; the number of these [subdivisions] over the circle of the constellations comes to **21,600** [כ"א אלף ת"ר; and indeed 360 × 60 = 21,600]. And each minute they divided again into sixty parts, and these parts were called **thirds**; and each third divided again into sixty **fourths**; and so on to fifths, sixths, sevenths, eighths, ninths, and tenths.

[Colophon, at the foot of both columns:] בעזר קוננו נוצר ישראל · **סיימנו השער הראשון** — "With the help of our Maker, Guardian of Israel — We have completed the First Section." [reading of the opening words [?]]

השער השני (The Second Section)

In it will be explained the making of the globe resembling the celestial sphere — [according to the number of] its principal circles [?] — and the construction of an observing instrument [כלי מחזה]; and my method for finding the height of the northern pivot above the horizon in every place; together with further matters pertaining to it.

סימן לא — The nature of the globe resembling the celestial sphere, its diameter and its poles

After we set out the order of the [four] elements [?] — [with a clear] arrangement of the order of the nine spheres of the heavens, one above another, all in great brevity — it is now fitting [for us] to return to the globe, and to lay out for the students the [principal] methods [?], and to examine the circles of the eighth firmament [?], the globe from which one takes the pattern and likeness of the celestial sphere. For from the making of this very globe the students will come to know the root and foundation of the science of the stars and the constellations.

You should know that the making of such a globe, resembling the sphere of the heavens, is done by two [methods]: The first is to make a **hollow spherical globe of thin bands** (and it is called a *sphera*) [ספירא] [?] … a globe [as a solid] body [?], encompassing [it] [?]. And I say to the students that they may choose either this

one or that, for both are equally good; the difference between them is only this: that the globe [made as a solid] body — upon it you can draw all [?] the stars of the heavens, which is impossible to draw on the hollow globe [in its hollow] [?] and its encompassing surface [?]. [This pedagogical passage is degraded — several clauses [?].]

[σ31 continues in the left column:] ...[the young students], for whom [the solid globe] is in every way finer and easier for explaining and clarifying the matters of the science of astronomy [?]. For the ten circles of the globe, which will be explained [?], are more recognizable and visible to your eyes on the hollow globe [?] ... and the wonders which [the authors set down] in books [?] ... as parables and experiments, are founded upon the fixed constellations [?] ... and are also more clearly [presented] to the students on the hollow globe [?]. [Heavily degraded — [?].]

[σ31 concludes, top of the right column:] ...the little ones. In any case [?], ... [whichever] of the two globes you connect [use] in your mind's eye, choose it [?]; and now that the explanation of the globe [has been given] [?], [the students] will contemplate both the solid globe and the hollow globe, for [only] a slight distinction and nicety is at issue here [?].

The globe from which the likeness of the heavens is taken must be a perfect sphere — not egg-shaped, not bean-shaped [?], but truly round in all its edges, its diameters equal in all their extents. In it is found no curve and no point, no corner and no [angle], and no [flat facet] [?]; nor is there in it any height or depth, high or low, length or breadth. (This is only by [convention], as [explained] further on in the seventh Section, siman [?109] ק"ט, and also in the third Section, siman [?60] ס', [on the verse] "Va-yikra" [?].)

"Kadur" — the word is from the verse (Yeshayahu 22:18), "[He will surely wind you round and round] like a ball [kadur] into a wide land"; and they call it in the vernacular *pelota* [Ladino/Spanish "ball"], which one throws and catches from hand to hand. And the [commentator] R"K [?] explained the root *kadur* ... which is known in the Mishnah as "ha-kadur," and which the sages call in the vernacular ... end of his words. That which in German [לשון אשכנז = ל"א] they call [ka'lin / Kugel?] [?] — within the globe [?] ... The globe you should imagine [as having] a point at its very center, because all the lines from that point to its circumference are equal in their measure; and this point is [called the] center (מרכז) of the sphere [?]. [The line drawn through it is the axis] [?].

סימן לב — The number of the globe's circles [and the circles] most necessary for the [complete] work, and the center [of the globe] [?]

[The great circles] are all equal [?] … the ten [?] great circles [into which the globe is divided] [?]; they are set by nature evenly [?] at [right] angles [?] … there is a place where they pass [?] … divided into 360 degrees, and there issue from them **ten circles** [עשרה עגולות] [?], one of which [?] … divides the globe into two [halves] [?] … Before we come to explain the ten circles of the globe, I saw fit to draw and set before you, at the very outset, a likeness and model of the globe together with some of its circles — because it is impossible to draw a sphere with its [full three-dimensional] extents [?] upon a flat surface. Know, then, that this drawing represents [only] half a globe; picture it in your eyes as a bowl inverted upon [your] palms, and [understand] that the lines engraved and drawn on the circle upon the half-globe each represent half a circle [?]; and imagine that the other half of the globe, with the other half of its circles, is likewise sunk, hidden, and covered beneath the [surface] of the globe, and drawn upon it.

Diagram. A large hemispherical projection of the celestial globe (drawn as a circle crossed by several great-circle arcs dividing it into segments), captioned: **"Figure of a globe with its eight circles — two of them are omitted, for a reason to be explained."** Two spokes with star-marks (✻) project outside the rim at the two poles.

- ציר הצפוני — "Northern Pivot" (upper spoke) [?]
- ציר הדרומי — "Southern Pivot" (lower-right spoke, clearly lettered)
- Rim inscription (top, curved): "אופ… ארבע צירים" [?]
- עגול סרטן — "Circle of Cancer" (Tropic of Cancer), upper-center segment [?]
- נקודת ה… — center point [label uncertain — [?]]
- Further segment labels (partly legible): "קו משוה היום" (celestial equator) [?]; "עגול המזלות" (ecliptic) [?]; "הדרומי" [?]; "חצות היום"/"עמוד" [?]
- Outer rim great-circle labels (Rashi-style, degraded): several arcs are named but not reliably legible — [?]

[More than two labels are uncertain]

And you, the reader, as a beginner setting out to learn this science — prepare for yourself, and set in order [?], a hollow globe of thin bands proportioned to the size of the drawing that follows; or have a **lathe-turner** [דרעקסלער, German *Drechsler*] make you a hollow globe [of wood?] [?], or [one made] of some other

material; and engrave upon it all the circles of the [meridian?] lines [?] upon its surface, and run the lines round about the globe.

שער ב (Second Section) — continued

(Continuation of the preceding paragraph, on constructing and marking a celestial globe. This material carries over from the prior batch; the first numbered heading on this opening is סימן ל"ד, which implies the globe-construction paragraph is סימן ל"ג.)

on a small globe according to its smallness, on a large one according to its largeness, and on each according to its size — [with the length and spacing of the marks] near or far in proportion [?]. And if God has granted you a heart to understand, it will be easy for you to grasp and to comprehend the design of this globe and how it is made, from these books of his — without any teacher or instructor. But do not rely on the drawing on a flat surface, for [?] the work will prove hard for you and you will not be able to complete your task by it. Rather, prepare for yourself a globe — [solid or] hollow [?], well-made and of one piece — and then you will succeed and gain understanding.

סימן ל"ד — Explanation of the First Circle, called the Equator (משוה היום)

The first circle, which we shall begin to explain, is the circle that runs around the middle of the globe and is drawn from west to east at an equal distance between [the two poles], the northern and the southern, passing over the center of this globe [and running] from [south to] north — that is, [?]. [At its ends] lie the pole of the world [קוטב / ציר], and the two endpoints of the axis are the two pivots called the poles of the circle, as was explained above [in siman ?]. This circle is called in the books by several names: *mashveh ha-yom* ("equalizer of the day," the equator), the "circle of the plain" (עגול המישור), the "straight circle" (עגול הישר), and the "equal line" (קו השוה) — and each of these names has its reason.

It is called *mashveh ha-yom* ("equalizer of the day") because for all who dwell beneath this line, day and night are always equal, all the days of the year. Moreover, when the sun runs beneath this line — which happens twice a year, when it reaches the head of Aries [ראש טלה] and [the head of Libra, ראש מאזנים] — the measure of day and night is equal for all the inhabitants of the world, in every clime, as will be explained. It is called the "circle of the plain" (עגול המישור) because those who dwell beneath this line see the two poles [on their horizon], and the globe of the earth appears to them as a flat plane [?]... [the extreme lines

meet; a body sunk below is hidden — one of the poles concealed]. And this is called the "straight circle" (עגול הישר), because the [horizon] stands upright at right angles to it, so that it is a straight line for them [?].

This circle of which we have now spoken you shall divide into 360 [ש"ס] parts, which are called degrees; the uses of this division will be explained to you later. And so that this division may be done correctly, [begin marking] one part [at the head] of the circle [?]. This is done by means of a compass [מחוג], [dividing it] into four quarters, and each quarter into [three?] parts [?], and each of those parts again into three parts, so that all the parts come to [the full number]. Now on a small globe, which because of its smallness cannot [hold] all 360 parts for marking with a graver [?], you shall mark the encircling line every ten degrees — 10, 20, 30, 40, [50?] and so on — so that they come to 360 [?] degrees; whereas on the **large globe**, [you divide it further].

You shall divide each [degree into smaller parts] [?]... [so that the sum of the parts is 72? / 60?] [?], each holding five parts [?], degrees up to [60?] — 10, 15, 16 [?] — and likewise minutes [דקים], and they too come to [72?], and so on [?]. This division [is made] on this "straight circle," and likewise you shall [make] on it, in every quarter of it, large [subdivisions], each of which is divided into [ninety] degrees [?]; for the whole is such that it is divided into four quarters, and each quarter into ninety [תשעים] parts, so that the sum of all the quarters is 360 [ש"ס] degrees, as will be explained further, God willing.

סימן ל"ה — Explanation of the Second Circle, called the Dividing Circle (אופן המפריש / the Horizon)

The horizon (*ofeki*), or the "circle of vision" (עגול הראיה), or the "ring of the earth" (חוג הארץ) — and in most astronomical books they call it *ofek*, which is likewise an Arabic word [Arabic: *ufuq*, "horizon"]. This circle too is one of the three great circles of this whole globe. It runs along the curvature of the eighth sphere, and its circle is inscribed at the very lowest place — where, according to the sight of the beholder's eye, the edge of the heavens and the edge of the earth appear joined together. This line is traced in the mind from the southeastern corner, going around the whole eastern side, and likewise the whole northern side, and thence to the west, and from the west to the south, until it returns to the southeastern corner. The center of this circle is beneath the soles of your feet, and the point directly opposite it above, in the zodiac, is called the zenith [(transliterated term) [?]; קדקד, "the crown of the head"]. That point serves as a pole for the horizon — that is, for the circle of vision — of every person, in whatever place he dwells.

And the arc — that is, the line of the circle that rises from the horizon straight upward, following the curvature of the sphere, up to the zenith [Gloss: opposite the crown of the head, which is the [24th?] part [?] of the sky] — is called the "circles of altitude" (עגולות גובה) [almucantars]. By them we reckon the altitude of the sun, the moon, and the other stars, in every place and at every time, and how many degrees and minutes each of them stands above the horizon, as will be explained regarding this later [in siman כ"ב? [?]], God willing.

And this circle of which I speak is called the "dividing circle" (אופן המפריש), as above, because it divides and separates between the stars that are above [the horizon] and the stars that are hidden and concealed from us below it. For this same reason it is [also] called the "circle of vision," because our sight extends only up to the circle of this line; whatever is below it is hidden and concealed from us. On the eastern side of this line we see, each day, the sun as it rises and shines forth; and on the western side [it sets]. And because of the [inclination] of the zodiac, the [arc] over which the sun revolves above the horizon is called by some authors the "arc of the day" (קשת היום), while the part below it is called the "arc of the night" (קשת הלילה). And just as the rule of setting applies to the sun with its rising [?], so the same rule applies to the moon and to the other stars that [rise and set].

They see [rising] above the horizon, every night, from the eastern side [stars] that then set below it on the western side. And know that for all who dwell round about the earth, in every place and at every time, their vision reaches above the horizon on every side, up to the eighth [sphere] — which is called the sphere of the stars, or the sphere [of the zodiac] — and always half the sphere, namely six of the [zodiac] signs, is revealed to them above the horizon, while the other half of the sphere of the firmament, namely the other six signs, is hidden from them beneath the horizon. Yet the eastern half of the sphere is [continually] rising to them [as the western half sets] [?]... [each day the eastern half rises and the western half sets, and over the course of the year all the signs rise and set for them] [?].

The [right] horizon (אופק ישר) belongs only to those who dwell beneath the equal line [the equator]; and their [horizon is called the "dividing circle"] [?]... [it passes over the two poles of the world]. [For such dwellers, the horizon divides the sphere in a particular way,] as will be explained; and moreover, there are many special laws and rules, distinct and set apart, that belong to those who dwell beneath the equator — to the north side and likewise to the south side:

- **The first:** their advantage [is that] one of the sides [dips down] from the horizon [?], and [the other] side [rises] from the horizon [?].
- **The second:** that some of the stars are always visible to them and some are always hidden from them [?] — [rather, for equator-dwellers all the stars both rise and set] [?].
- **The third:** that the time in which the signs of the zodiac revolve above the horizon is equal to the time of their revolution below the horizon.
- **The fourth:** likewise, the time of the sun's revolution above the horizon [equals its revolution below it]. From this [it follows] that the measure of day and night is never equal [for the rest of the world] except on two days of the year, as will be explained in siman [?142] קמ"ב [?].
- **The fifth:** that their horizon also divides [every circle passing straight] into two equal parts, though not at right angles [?]; and it becomes for them a straight line from the side, like a stretched wall-line [a plumb-line] [?].
- **The sixth:** that those who dwell beneath the equator... [see the] signs inclining from them toward the south, all of this according to their nearness to the [northern] pole; so that whoever [moves] from the equal line toward the northern pole by [24?] degrees [?], all twelve [י"ב] signs [?] will be [inclined] to the south side for him [?].
- **The seventh:** that of the half of the globe which lies from the [equal] line toward the north, the part called [the visible] [?] will be [hidden] from them beneath the horizon [?]; and the half of the globe from the equal line toward the south will be hidden from them.

The dividing circle, or the horizon: according to [?]... [how to inscribe it upon the globe] — [set the seat/base ring] [?]...

above the ring of the "seat" [base] itself, [in] degrees; and let there be [a seat-ring] like it [?].

The horizon — which is the one under discussion — is a ring; like it [the equator], you divide it into 360 [ש"ס] parts, or degrees, just like the equator-circle, only with a slight difference in the manner [?]: you divide it into four quarters, and each quarter you divide by itself into ninety [תשעים] parts, whose sum together is 360 [ש"ס]. And upon the four quarters marked on the horizon, they begin the count of the number of degrees of the east [point] on the horizon; and from there their number runs [from 0? up] to ninety, in the manner 9, 10, 15 [?] and so on [?].

סימן ל"ו — Explanation of the Third Circle, called the Meridian (אופן חצי היום)

The third circle is called the "circle of midday" (אופן חצי היום, the meridian); it is also called the "southern circle." It runs along the curvature of the firmament from the middle of the north to the middle of the south, and so from [south] to north, and passes over the two poles of the world — that is, over both poles [?] — and over the point at the zenith (the crown of the head). It divides both the equator and the horizon-line, each of them, into two equal parts and at right angles. Its property is that... [as its] center [moves] each and every day to pass beneath it [at the moment of noon] [?], the time of midday reaches all who dwell beneath it...

and [reaches the easterners] before the westerners; thus [the sun] comes to the easterners before the westerners in every place. Yet [this happens] not at every time, but only at the seasons of Nisan and Tishrei [the two equinoxes]; whereas in the rest of the days of the year there is precedence for the northern [places] before the southern [?], in such a way that in some places the east [reaches noon]... [before the westerners] [?], as will be explained [in siman] ?קל"ב–קל"ג [?133–132 [?]].

And from all these matters [you may learn] the two distinctions that exist in the world [?] concerning the difference between the meridian [אופן הקוים? [?]] and the rest of the circles of the globe. The first: that every circle of the other circles of the globe remains in its place for each individual person and for the whole world alike, [whereas the meridian is shared] [?]... [each person's meridian differs, while it is shared by all who lie due north and south of one another] [?].

סימן ל"ז — Explanation of the Fourth Circle, called the Zodiac Circle (עגול המזלות / the Ecliptic)

The fourth circle is called the "circle of the signs" (עגול המזלות, the ecliptic) [Ladino/Greek term [?]]. It is one of the great circles that revolve about the whole globe. It passes over the equator and divides it into two equal parts, though not at right angles, for it crosses it at two opposite points [the equinoctial points] distant from one another by [?] degrees. It cuts across a broad path [the width of the zodiac]... [inclined by about 24 [?] degrees / minutes] [?], and the pole of the [ecliptic]...

[the ecliptic is divided into degrees, into minutes;] and [the signs are divided into] the northern [signs] and the southern [signs] [?]... [those inclining to the north

side are called the northern signs, and those inclining to the south side are called the southern signs] [?]. [There are... degrees] [?]. Know further that although the [ecliptic] has its own center [?], because of its inclination from the equator toward the north and toward the south, it necessarily follows that the poles of the [ecliptic] of which we have spoken are not [in the same place] as the first [poles], [as in siman א"ל? [?]]; rather, the poles of the ecliptic are distant from the poles of the world according to the inclination of the ecliptic from the equator.

[degrees, to divide them into equal minutes] [?]... the [northern signs] and the [southern signs]... those [inclining] toward the south side are called the southern signs. [There are... signs] [?]. Know further that the circle of the zodiac, although [it has] its own center [?], because of its inclination from the equator toward the north side and toward the south side, it necessarily follows that the poles of the circle of which we spoke are not [as at first, in siman ?] [?]; rather, the poles of the zodiac are distant from the poles of the world according to the inclination of the signs from the equator, [in accordance with] their inclination, which according to the view of Ptolemy [בטולמיא״ס] is 23° [כ"ג] [and 51 minutes?] [?] — by that much are the poles of the zodiac distant from the poles of the world, as will be explained further.

סימן ל"ח — Explanation of the Fifth Circle, called the Poles [Circle] or Support of the Sphere (צירים או מעמד הגלגל)

The fifth circle is called the "support of the sphere" (מעמד הגלגל), and it is also called [the solstitial colure] [?]. [Together with the sixth it makes] two circles which are among the great circles that revolve [around] the thickness and body of the globe, [running] from the south to the north; and at the place where the two colures [מעמדים] cut [one another] at right angles [?], [it passes] like the first [circle]. This [circle] passes over the [ecliptic] [?] (whose distances are as stated above), and this circle runs by way of the [summer solstice] and by way of the head of the sign Capricorn [ראש גדי] [and the head of the sign Cancer, ראש סרטן — the two solstice points] [?].

these are called [thus]: this circle has two names; it is called the "colure [standstill] on high" [?]. The two solstice points, which are the summer [solstice] (קיץ) and the winter [solstice] (חורף), are called "standstills" (מעמדים) [?]; and [one may] call it "the circle of the four poles of the spheres," and [one may] call it "the circle of the summer and winter solstices."

סימן ל"ט — Explanation of the Sixth Circle, called the Equinoctial Colure (מעמד השוה)

The sixth circle too is called a "support of the sphere," because within it are found two other "standstills" [?]. This circle also revolves by way of the two poles of the [sphere], the northern and the southern, at which place the two colures cut one another; [it passes] through the two [equinoctial] points, [at] the head of Aries [ראש טלה] and [the head of Libra, ראש מאזנים]...

[the sixth circle passes through the two equinoctial points — the head of Aries and the head of Libra — cutting the ecliptic and equator; and it is called the "equinoctial colure" because when the sun stands at those points, day and night are equal] [?].

סימן מ' — Explanation of the Seventh Circle, called the Summer-Solstice Standstill (עמידת הקיצית) / the Circle of Cancer (עגול סרטן)

The seventh circle is called the "circle of Cancer" (עגול סרטן); it is also called the "circle of the summer-solstice standstill" (עמידת הקיצית). For when the sun reaches the head of the sign Cancer [ראש מזל סרטן], there it is nearest [to the zenith of the northern dwellers], in the extreme of nearness — for then it can come no nearer to us. This is the end of the days of [spring] and the beginning of the days of heat [summer] [?]. On that day the sun makes the circle [ק' ?] [in the season of...] its daily motion; and this is the circle of [the summer standstill] and the [tropic] [?]...

(Continuation of סימן מ — the Circle of Cancer / the summer standstill, begun at the foot of the previous page.)

so it comes about at the summer solstice (תקופת תמוז), with its heat: at that season the day is longest for us of all the days of the year, [the night is shortest,] and the heat too then grows greater for us than in any other days of the year. The declination of the center of the sun from the equator at that time is, according to Ptolemy [בטולמיא"ס], 23°51′. The astronomers call this declination "the great declination," since no [solar] declination of this kind is found greater than it. This circle is also called "the reversing circle" (ההפוך), because from this point the sun begins to turn its face toward the south and to withdraw from the inhabited world day by day, and the days of winter — that is, the winter season — draw nearer to us, until it reaches the head of Capricorn, which is the utmost of its withdrawal from the inhabited world, as will be explained shortly.

From the principles we have set out it becomes clear to you that all who are more than 24 degrees from the equator [toward the north] — such as the inhabitants of

Babylon, Persia, Media, Chaldea, Egypt[?], Spain, France [ספרד לרפת], Greece [יון], Italy [ואטליה], and countless other lands — the sun never passes over the zenith (the crown of the head) of the inhabitants there, over all the choice, settled part of the world; rather the sun always passes to their south, because the sun never crosses beyond the Tropic of Cancer for all the days of the world. And just as this is the rule for the northern dwellers, so it is for the southern dwellers who are more than 24 degrees from the equator toward the south: the sun circles around to their north all the days of the world.

סימן מ"א — Explanation of the eighth circle, called the winter standstill (עמידת החורפי), or the circle of Capricorn (עגול גדי)

The eighth circle is called the circle of Capricorn [עגול גדי; also read עגול נריינם? — reading uncertain], and it is [also] called the circle of the winter standstill (עמידית החורפית). For when the sun reaches the point of the head of Capricorn, there it stands still and ceases to withdraw any farther, since the sun is then at the extreme of its distance from [the inhabited world] and can go no farther. At that moment is the end of autumn and the beginning of winter. On that day the sun makes one full circle [about the earth] by the diurnal motion, [and this] circle is the lowest, and the sun stands closest [to the horizon] toward the south of the year. This occurs at the winter solstice (תקופת טבת), the time at which the day becomes shortest for us and the night longest, and likewise the cold grows greatest. There the distance of the sun toward the south is 23°51′ [ק"נ/כ"ג מעלות; degrees read as 23 by symmetry with the northern value, minutes flagged].

Know, too, that this circle is called "the reverse of the [summer] one" (היפך הקיץ), because from there the sun begins to turn its face back toward the north, to draw nearer to the inhabited world day by day; and the summer season likewise draws nearer to us day by day, until the sun reaches the head of Cancer — and so this matter recurs in a cycle continually, all the days of the world.

From the things we have mentioned it becomes clear to you that the difference between the extreme of [the sun's] withdrawal from the inhabited world and the extreme of its approach [to it] is 47°42′ [מ"ז מעלות מ"ב דקין = twice the obliquity]. You should also know that the distance between the two circles — between the Tropic of Cancer and the circle of Capricorn — since the sun is always confined moving between these two bounds [is 47°42′]; and this was the view of all the ancients [כל דעת הקדמונים], the [Greek: πλανώμενα? "wanderers"] planetary bounds [reading uncertain, ~two lines here are garbled], and it is enough to be brief about this. **

[Gloss, small type, largely illegible: "שם שום … כמו … ע"ה … עז" — a short marginal/footnote line above the next siman, mostly unreadable on the scan.] [?]

סימן מ"ב — Explanation of the ninth circle, called the northern circle (עגול הצפוני)

The ninth circle is called the northern circle, and it is traced around the pole of the ecliptic [קוטב של עגול המזלות]. How so? We have already explained above that the ecliptic is inclined to the equator by 23°51′ [כ"ג מעלות נ"א דקין; degrees clear, minutes read נ"א per the established obliquity]; accordingly, the axis of the ecliptic is likewise inclined by that same amount. Now since the ecliptic is carried around by the diurnal sphere, it follows that the axis of the ecliptic revolves and traces a full circle around the axis of the world; and this circle is called the northern circle, for no circle traced in the making of the celestial sphere lies nearer to the north pole than it does.

From the principles we have mentioned it follows that the distance of this whole circle from the north pole is also 23°51′, and that those who dwell beneath this circle are, by this reckoning, 66°9′ [$23°51′ - 90° =$ ס"ו מעלות ט' דקין] from the equator — and by that many degrees the north pole is raised for them above their horizon. For those dwelling beneath this circle at the summer solstice (תקופת תמוז), the day lasts 24 hours [כ"ד שעות], as will be explained further on, siman 143[?] [סי' קמ"ג — cross-reference number uncertain].

סימן מ"ג — Explanation of the tenth circle, called the southern circle (עגול הדרומי)

The tenth circle is called the southern circle, and its tracing is like [that of the ninth]: because the ecliptic sphere, through the diurnal sphere, causes the axis of the ecliptic to revolve around the axis of the world toward the south. The cause of this was already set out just above in [the discussion of] the ninth, northern circle, and that very same cause holds for the tenth, southern circle — for as is the case with the one, so is the case with the other; therefore it needs no separate explanation.

And behold, we have now traced out for you ten circles of the sphere, the ones most necessary for the science of the stars and the constellations, in constructing a sphere resembling [the heavens]. There are also many other traced circles besides these; for each and every day of the year [the sun traces] a distinct circle — these are called "the daily circles of the sun" (גלילי השמש), as [will be explained]

further on in this gate, siman 132[?] [סי' קל"ב — number uncertain] — and likewise the path that each star and the fixed stars trace, making each day a circuit around the sphere of the world. Were all these to be drawn as circles upon the sphere, [it would be crowded beyond use]; [therefore we drew only] these [ten], upon the sphere. [?]

סימן מ"ד — Explanation of the distances of the three circles — the equator (קו הישר), Cancer (סרטן), and the Northern circle — from one another

From the principles we have mentioned — that just as the ecliptic is distant from the equator, so [each corresponding circle is distant] — it likewise follows what the distance of the whole northern circle is from [the north pole], and likewise the distance of the Tropic of Cancer from the equator. And it becomes clear to us, without much reflection or extensive calculation, how great [each of these distances is]:

The distance between the Tropic of Cancer and the northern circle: the distance of Cancer from the equator, and likewise [the distance] of the northern circle from the north pole, and from the equator to the north pole in the sphere is, as already explained, 90 degrees. Now the two [component] distances we mentioned — namely the distance of the Tropic of Cancer from the equator, and the distance of the northern circle from the north pole — each of them is 23°51′; joined together they come to 47°42′. Subtract this from [90 degrees], and there remain 42°18′ [מ"ב מעלות י"ח דקין], and that is the distance between the Tropic of Cancer and the northern circle, as follows by this reckoning. And from the equator up to the northern circle there are 66°9′ [ס"ו מעלות ט' דקין], and this itself is [also] found [as the distance] from the north pole down to the Tropic of Cancer.

These, then, are the measures and distances that always obtain among the three circles — the equator, Cancer, and [Capricorn / the Southern] — and [so too] for the southern side; and remember these matters, for [we shall need them] in their place. ** [?]

סימן מ"ה — Explanation and construction of the meridian line (חצי יום) by another method, with its great usefulness

After we have explained the circles of the sphere in a general way, [we turn] further to explaining and constructing the meridian line (אופן חצי יום) by another method. For this instrument you are to make yourself, from wood or from brass

[מנחושת?] or from some other [material], a hollow ring, like a signet-ring [כפי טבעת], whose hollow and thickness run along the diagonal of the sphere; and this will serve you as the meridian ring [אופן חצי יום], like the [earlier] arrangement of the meridian. Its hollow should be like [the section?] of a ring, and its thickness about a quarter of [a finger / הליפורין?] or less, of about this measure. On this ring you make two [markers / כוכבים? "studs"] opposite each other, such that a [thread/rod] may pass through the two holes; and within the two holes you set the two poles [קוטבי] of the [sphere], at the place of the two poles of the sphere, so that the ring and the sphere [turn together on] a single meridian ring. This you take within the ring of the [horizon-and-diagonal] frame [טבעת הכסא?], as explained in siman 35[?] [בסי' ל"ה]; and in it you make two slits [חרירין] opposite each other, [set] in the middle, and the [pointer / הצפון] of the frame at the middle of the [south]; and the [thickness of the] slits should be about a quarter of the thickness of the meridian ring. Within these two slits you fit [the meridian line], and you erect this ring so that the two poles [קוטבי] — the diameter of the [sphere?] — are the two points of the ring, standing true to the horizon, with the meridian ring standing upright and true, high [at the top] and low [at the bottom]: the upper semicircle rising toward the point of the zenith [נכח נקודת הקדקד], and the lower semicircle bending down toward the point [opposite it, the nadir], between [the pointers?]; [thus the sphere is set up] toward the [zenith] point, or the crown-point above. And this will give you [the meridian line] of the upper ring — the meridian ring — upon which, when the sun [transits] this line, it is the time of local noon [חצות היום], as [stated] in siman 35[?]; and [the point] of the lower [semicircle] will be for the midnight line, upon which, when the sun [is on it], it is the time of local midnight — in every place and at every time — as will be explained at the end of this gate, in siman [?] [בסי' ב"ל? — number illegible], God willing. ** [?]

[Rashi script / small-type note: "האופן חצי יום — of which we have also spoken; in it too will be marked … a [circle] upon the sphere, like the [inclined?] ring … [reading uncertain]."] [?]

(Continuation of סימן מ"ה, top of the next column.) …For the four quarters, and every fourth [division] — for its whole [circumference] is divided into 360 parts [reading of the fractional scheme uncertain], so that each quarter is 90 parts — and the tracing of the 90 [degrees] should be made [upon the ring]; this will be the meridian ring, which serves the whole surface of the sphere. The benefit of this is that by it we can know, at any point on the surface of the sphere, [the position of any marked object]; and the meridian line thus fixed [gives] the noon [transit]. [?]

סימן מ"ו — To construct, upon a globe resembling [the heavens], an arc — after measuring the distance [of the stars, הכוכבים]

Know that I have seen [in a certain place], as the astronomers [do]: on a [fine-graduated] quadrant [קשת רביעי — a quarter-circle] of a sphere, its rim is marked with ninety degrees; and to this we return [to draw] a circle [serving as] the meridian at the place opposite the point of the zenith at the horizon, [mounted] so as to move upon the axis around [the sphere], over the whole surface of the sphere. And the benefit of this construction is that by it we can know and find, upon the sphere, by inspection at first glance [בסקירה ראשונה], the points opposite the zenith; and also to know and to measure with it the distance of everything marked on the sphere — how far each is, whether from the horizon, or from the equator, or from [its own] place [i.e. its coordinates] — all ready and set out, without any labor or calculation whatsoever.

סימן מ"ז — We establish that the horizon line (קו האופק) and the meridian line (קו חצי היום) are shared by two people distant from one another

Know: for Reuben and Shimon, when they are at the utmost distance from one another, the horizon line, and likewise the meridian line, are both shared by the two of them. This is the case when Reuben dwells at the eastern edge [of the world] and Shimon dwells at the western edge — and so in any place in the world where two people stand with the body of the earth intervening between them, their zeniths directed opposite one another: the horizon line is shared by both, and so too the meridian line. This meridian line [is such that] when it is midday-transit [חצות יום] for Reuben, at that same line it is midnight [חצות לילה] for Shimon; and when it is midday-transit for Shimon, it is midnight for Reuben. So the matter goes, and this holds forever.

The horizon too is shared in this way by the one standing on the surface of the earth and the one standing opposite him beneath the earth: both share a single horizon, except that the half which is above [the earth] for the one is the very same half that is [below] for the other, and the eastern horizon of the one is the very same as the western [horizon] of the other; and the moment of sunrise for the one is the moment of sunset for the other, and the moment of noon for the one is the moment of midnight for the other; and the [span of] day for the one is, from its beginning to its end, the very [night] for the other. For [when] the night

of the west is the whole of Shabbos day at the eastern edge, and the whole of Shabbos eve [Friday night] at the eastern edge is the whole of Shabbos day at the western edge. (I wrote at the beginning [of this discussion] that each day begins at the eastern edge — at all events, [see] at the end of the third gate [בסוף שער השלישי].) From all the things mentioned it becomes clear to you [what follows] when Reuben dwells at the eastern edge and Shimon at the western edge, according to the order of the earth and what is suspended [above and] beneath it... [?]

סימן מ"ח — Just as a person is distant from beneath the equator toward its north, so is the distance — or the height — of the axis (the pole) above his horizon

Know that the distance of the point opposite the crown of every person's head [the zenith] from the equator, toward the north, in every place, is always exactly equal to the distance — or the height — of the north pole above the horizon of his view. And [equal to] the height of the north pole [above] the horizon of his view is the distance of [that point's rays] from the equator. That is to say: whichever of these two you know, or is made known to you, the other [is thereby known] to you, without any need of calculation... [a general statement follows, the middle of which is degraded]. As many degrees as a person is distant from the equator toward the north upon the earth, so many degrees is the north pole raised and set for him above his horizon; and this is [a consequence of] the sphericity of the earth and of the sphericity of the ecliptic sphere, as will be explained further, God willing, in gate 3 [שער ג'].

סימן מ"ט — All the stars near the north pole never set for us

From the principles we have mentioned it will become clear to you, [as one may verify] readily in the construction, that all the stars near the north pole (within [an arc equal to] the height of the pole above one's horizon, or within [the distance of] the points opposite the zenith from the equator) are always seen by us above the horizon and never set for us. And correspondingly, the same will hold for us with respect to the south pole: that all the stars near the south pole (within [an arc equal to] the [distance of one's] zenith-ray from the equator, or [equal to] the height of the pole above our horizon) are always hidden from us. All such matters are seen sensibly [בחוש] on the globe-instrument, when you tilt it to the height of the [pole/equator] line of your location and turn it about — [and then] it will become clear to you, [as one may verify] readily, that stars farther from the axis than [the pole's height], or [nearer] than the height of the axis

above our horizon — behold, [such] a star [rises and sets]; while a star near the equator [remains above only briefly]; and a star far from the axis and near the equator, and toward the south, is the reverse of this. [?]

סימן נ — To find the meridian line of the south (קו אמצע הדרום), and to see sensibly the days of the four seasons (תקופות) of the year

Since the knowledge of the southern meridian line (that is, to know the line and the time of local noon at every place and at every time) is of great necessity for the studies and for many matters that lie before us, and many great things depend upon it… I have seen fit to instruct the students [and] to fill this [gap] for every place and every time.

Take yourself a board (דף) … and [level] its whole surface; and though [you already know] the place [and] rising of the sun, return it to your horizon without any inclination to the sides, and hold it fast so that it does not move, or shift, or tilt. Take a compass (מחוגה) and inscribe upon it one circle around the [center] point ה; and take a small, thin rod [עמוד קטן דק, a gnomon] whose length is less than half the diagonal of the circle, and fix it at the center of the circle, at the point ה. [At the top, from above,] …

Diagram. A circle (the shadow-circle / horizon disk of the gnomon construction) with a central point and radial division-lines dividing it into eight sectors (a vertical and a horizontal diameter plus two oblique chords). Cardinal words are lettered large and bold outside the rim; single Hebrew letters mark points on and within the circle. This figure belongs to סימן נ (finding the true south line and the seasons from the noon shadow). More than two point-letters remain ambiguous on the scan even under magnification.

- מזרח [East] — large bold, at top, outside the rim
- מערב [West] — large bold, at bottom, outside the rim
- ה [he] — center point (foot of the gnomon)
- ז [zayin] — point on the circle, upper region
- ח [ḥet] — point on the circle, lower region
- ד [dalet] — point left of center
- ב [bet] — point near center
- א [aleph] (position uncertain) — [?]
- ג [gimel] (position uncertain) — [?]

- ו [vav] (position uncertain) — [?]
- [large bold letter(s) at the far outer-left of the rim — possibly a further cardinal word (צפון/דרום?) or point-letters; illegible] [?]

Draw a line from point א through [the center] to point ב — this is line ב־א; and mark the points on this circle [where the shadow-tip fell, forming] the end of the arc. Then divide [that arc] into two equal parts at the point [נ / the midpoint], and mark it, and [the bisecting line] will pass along the diagonal [ז־ג?], [which is] the meridian (חצי יום) for all the days of the year: whenever the gnomon's shadow reaches this line, it is the moment of local noon for you and for all who share the same longitude of the world, as [explained] above in siman 36 [ל"ו] and siman 45 [מ"ה]. And, more precisely, [for] those who lack [instruments] — where there is a deficiency or a defect — they make [the construction] in the manner described.

And to discern the days of the seasons (תקופות) of the year by means of this gnomon and board, there are two methods: one, to test with it only the days of the Nisan and Tishrei seasons [i.e. the equinoxes]; and by the second method, to test with it all the days of the four seasons. This is done thus: draw another diagonal, from the middle of the east to the middle of the west, passing through the center of the circle at point ה [reading of the intermediate point-letters uncertain] — this is the diagonal א־ה־ד[?], which is parallel to line כ־ח; and since line א־[ק]־ד[?] passes through the middle… [it marks] the true east-west; and by means of it, on the days of the equinoxes of Nisan and Tishrei, [the shadow will fall exactly along it]… In this way you can recognize the days of the two seasons of Nisan and Tishrei.

But to discern all the days of the four seasons of the year — [note that the noon shadow] changes its order [i.e. its length] each day: on the day of the summer solstice (תקופת תמוז) the shadow is [shortest], and it goes on lengthening until [the winter solstice of] Teves — and for all northern dwellers [it reaches] the utmost [length]…

(Continuation, top of the next column.) …the [winter] solstice of Teves: the shadow goes on lengthening day by day until [that day], and it grows shorter again toward the seasons of Nisan and Tishrei, [the shadow falling] between the two extremes of the [solstices of] Tammuz and Teves. And if a person watches this shadow [and its] circuit at the four seasons — [the full course] of its day at its four measures: the extreme of length [at Teves] and the extreme of shortness [at Tammuz], and the two intermediate measures [at the equinoxes] — a person can know the days of the four seasons truly. But for exact reckoning of the hours and

the [divisions], there are other methods and calculations, and this is not their place.

סימן נ"א — Constructing the first viewing instrument (כלי מחזה), called the "square instrument," and in the Latin tongue "quadrant" (קוואדראנ"ט)

Said the author [אמר הכותב]: [Greek/Latin term illegible — "טרס טופי הלום"?]. I saw fit, at the close of this gate, that it should serve to instruct and enlighten the students in measuring the height [altitude] of the sun, of the moon, and of the other stars, by means of a single instrument — the square instrument [כלי מרובע, i.e. the quadrant] — to know with it, in any place, how many degrees and minutes is the altitude of any star above the horizon, and likewise to know how many degrees and minutes is the height of the north pole above the horizon, in every place and at every time. We have already composed a separate treatise on this [subject], and its proper place would have been here; but only because I did not wish to burden the students, or to hold back the learners of the other gates that lie before you, I have assigned the matter of measuring the height of the stars and constellations — and likewise the measuring of the height of the north pole — to the end of this book, [in gate 11 (שער אחד עשר) / and gate references, the several numerals here being garbled] [?], the [gate] in which we have expanded the explanation with many examples, God willing. Yet since there is need of it for the third gate — together with the tenth gate that lies before you — we have great need of measuring the stars… for in truth many matters depend upon them. Therefore I saw fit to reveal to the students, even here, a little of the matter of this measuring, [if only] by a small and brief note. Attend and hear one of the methods of this measuring:

Make yourself, from wood or from metal, a board [דף] whose shape shall be, in general, a quarter-surface of the circle [i.e. a quadrant], which we mark in the figure before us א, ב, ג. Call the [right-angle] corner of this instrument — the point א — the center of the instrument, for a reason that will be explained at the head of gate 11 [שער י"א], God willing. Along the rim of the instrument, marked א, ב, ג [and] the arc ב, ד, the arc which is here [to be graduated]: divide this arc into ninety parts. (And this division, to enlighten the students by an easy and finished method, has already been explained above: first it is divided into three parts, and each of those into three parts, making nine parts; and each one of these is divided into two, so that now there are eighteen parts, each one of which stands for five degrees. Mark these below, along the arc of the instrument — thus: 5, 10, 15, 20,

and so on up to [90]. And the interval between mark and mark divide into fine lines, each of them into [several] parts, so that their sum is ninety; and these are called degrees.) All this you shall make set right, according to its rule, and according to the figure [depicted]. This arc, upon which the numbers of the degrees are inscribed, is called "the arc of number" (קשת המספר), because [the degrees] are counted upon it. And from the [center, past] the numbers of the degrees, draw one plumb-thread (קו חוט) … [continues].

שער ב (Gate Two) — continued

סימן נ"א (Siman 51) — construction of the quadrant (continued)

for the way of the instrument is to draw the line א-ג [aleph–gimel], and the length of this line should be a little more than the length of the diagonal of the instrument; it is marked in the figure [as] ד-ח [?]. This line is called *the plumb-line* (קו המשקל), because upon it will hang a single weight of lead, to pull the hanging thread taut and straighten it downward. It is best to fasten it firmly to the corner and along the edge of the instrument's face, and at the corner [ח-נ [?]] opposite it.

Beneath it [the top edge], mount two small, thin pieces like pinnules (ניפורין [pinnules/sighting-vanes]), or [make them] of hollowed metal, and make in each one a small hole, so arranged that the two holes lie on a single straight line, aligned one directly opposite the other, along the edge א-ג of the instrument [the text writes חל"ף נימ"ל, i.e. אל"ף גימ"ל = the edge א-ג]. The holes should sit on the very edge of the instrument, or a little above it. In this way you will have a good and straight [sight-line], and the two holes through which one sights are called *the sighting-holes* (חורי הקבבטה). From this moment the instrument stands before us, prepared according to its rule; and the student who works with it will understand it, as [indicated by] your sign.

Diagram. A quarter-circle (quadrant) instrument. The right-angle corner at the upper left is the apex/center; two straight edges run from it — the horizontal top edge to the upper-right corner, and the vertical left edge down to the lower-left corner — and a graduated arc joins those two outer corners. Two pinnules (small raised sights) stand on the top edge. From the apex a diagonal line runs across the field to the arc, ending in a plumb-bob hanging at the lower right (the plumb-line, קו המשקל). The arc is graduated with Hebrew letter-numerals in two bands (the "arc of number," קשת המספר), running by fives from the top down to the bottom.

- א (upper-left corner): the apex / center of the quadrant (the right angle)
- ג (upper-right corner): outer end of the top edge, one terminus of the arc

- ב (lower-left corner): outer end of the left edge, the other terminus of the arc
- Along the arc: the graduation marks (Hebrew numerals, 5°, 10°, 15° … 90°) [individual numerals not transcribed cell-by-cell]

סימן נ"ב (Siman 52)

To find the altitude of the sun, and likewise the altitude of any other star — how far it is above the horizon.

Know that the astronomers give the name — for every place at which the sun is found, from the moment it rises in the east until it reaches the meridian (קו חצי יום) — of *the altitude of the sun* (גובה השמש); and likewise from the moment it descends from the meridian toward the west until it sets below the horizon, they call the place where it is found by the same name, the "altitude of the sun," meaning their height above the horizon, whether above the eastern horizon or above the western horizon. And as the rule is with the sun, so is the rule with every other star.

To find the altitude of the sun, or of any other star, take the aforementioned instrument in your hand by the corner [נ-ח [?]] of the instrument. Face the instrument toward the sky and aim it at the sun, [marking] at corner ג. Hold it close to one of the outer corners of your eyes, close the other eye, and look and sight along the edge of the instrument and through the [sight-]holes — through point ח [?]. Raise and lower the center of the instrument (which is point ח [?]) up and down, until you see, through the two sighting-holes, the center of the moon or of any other star whose altitude you wish to know. When this has been established for you, look at that moment below, at the edge [of the arc], [to see] how many degrees the plumb-line cuts off — and that is the number of the altitude-degrees you sought.

As for measuring the sun: because it is possible for a person to look through the sighting-holes toward its full brightness [and be dazzled], know that in measuring the altitude of the sun you need not look with your eyes directly at the sun; rather, only raise and lower the center of the instrument until the sun casts [its ray] through the two sighting-holes, and then you will see below how many degrees the plumb-line cuts on the arc of number — and that is the number of the sun's altitude above your horizon.

And know, dear reader, that all we have said in these two adjacent simanim we have made into simple, easy measurements for young students, without any complexity. The essential rules and principles of this measurement, together with

its great usefulness, will be explained to you later, in gate eleven (שער י"א), where you will find the nature and structure of this instrument, and hear it set out more clearly and more fully, God willing.

סימן נ"ג (Siman 53)

To find how great is the altitude of the northern pole (קוטב הצפוני) above your horizon, and the place of its point in the eighth firmament.

When you wish to know how great is the altitude of the northern pole above your horizon, in any place, take at the beginning of the night one of the stars that do not set below your horizon (these are the stars near the northern pole, high enough above your horizon, as [explained] above in siman 49). Watch one of the stars when, at the beginning of the night, it is to the east of the meridian; afterward the star will circle round with the diurnal motion through the west and reach the meridian (as I already showed you, your sign, in siman 50 [?]) — for then the star is at its greatest altitude above the horizon. Measure with the quadrant instrument (כלי הרובע) how many degrees is its altitude above your horizon, and keep the number of degrees found in your measurement. Then, after twelve hours, when the star circles round again through the east to the meridian a second time — and this time it is at its lowest [culmination] — measure likewise how many degrees is its altitude above your horizon, and keep this number too in hand, a second time. The mean (הממוצע) between the number of degrees of the first observation and the number of degrees of the second is the number of degrees of the altitude of the pole (ציר) above your horizon.

For example: when the star was at the meridian at its greatest altitude, its altitude above your horizon was 80 [80 = פ' [?]] degrees; and when it circles to the meridian a second time, at its lowest point, its altitude above your horizon is thirty degrees; and so the mean between the two numbers — [55°; value not clearly legible [?] — (80+30)/2 = 55] — is the degrees of the altitude sought. When this becomes known to you, you can also reckon upon the meridian the place of the point of the pole (ציר), similarly. And in gate twelve (שער י"ב) you will find three more correct and straightforward ways to count the altitude of the pole (גובה הציר).

[Foot of p. 45: the words גובה הציר appear at the page foot, with a further mark ל"ה [signature/gathering mark? — reading uncertain].]

סימן נ"ד (Siman 54)

To find the instant and time of midnight (חצות לילה), throughout all the days of the year.

We have already explained, as your sign [indicated], how to count the instant of midday (חצות יומם) [...]; and [now] to reckon the instant of midnight, which is of great [use] to us. Therefore know that the instant of midnight is the time at which the center of the sun reaches the meridian that is below the earth [the lower meridian]. Determine which degree of the zodiac (מזל) will stand opposite the center of the sun [...], take the degree diametrically opposite it, and observe the time of its arrival at the meridian — [that is] the time of midnight. For example: when the center of the sun is at the tenth degree [?] of Scorpio (עקרב), so that the sun [stands there] [...], then the [opposite] point on the western side of Scorpio which is below [...] the sun comes to the meridian [...], [and this is] the time of midnight [?]. Thus keep watch through the night: [when the point] the tenth degree above [?] the sign opposite it [reaches] the meridian above [...], that is the time of midnight.

Another method for finding the time of midnight: by [observing] the end of the motion of any of the fixed stars — [from when] it rises upon the horizon until it reaches the meridian, that is [half] of its course; from the meridian [onward] until it sets below the horizon [...], and the time of midnight is [midway]. Watch one of the stars at the beginning of the night [when] it rises upon the horizon, and observe the time [of its arrival] at the meridian — that is the time of midnight. But this reckoning does not come out exactly except by reckoning in "crooked" (seasonal) hours or [equal] hours, whose nature will be explained to you later, in gate four, in siman 101 (בסימן ק"א). By equal hours this reckoning holds good only on the days of the two [equinoctial] seasons, Nisan and Tishrei, on which day and night are equal — and understand this well, forever.

[Colophon, centered] He is One, and there is no second · May He requite me with all good · And in the paths of righteousness may He guide me · At the conclusion of the Second Gate.

השער השלישי (The Third Gate)

In it will be explained: the divisions of the earth, and how many parasangs (פרסאות) its measure; and an exposition of the seven climes (אוקלימים) and of the three parts of the ancient world; and the existence of the New World; and, in

addition to this, four [further] parts of the world; and the figure of the earth's form in its entirety — its paths, its landscapes, its regions — in all, from all its six extremities; and the reality of the longitudes and latitudes of the provinces (מדינות); and the boundaries of the four directions of the world, where they begin and where they end; together with an exposition of the thirty-two winds [compass-points] of the world, each of which is called by its own name; and a table (לוח) of the many places and provinces of the inhabited world; and of the length of days, how much each of them [runs] along the length of the world [longitude] and how much in their latitude — with many other matters besides.

Says the author: The third essay — [treating] the lowest foundation, [the earth], the lowest of the four elements (יסודות), which we have already begun in this our book. Accordingly, it was fitting for us to begin from below and ascend upward — unlike the order of others, whose "head reaches the heavens" [cf. Bereishis 28:12, Jacob's ladder], setting the heavens first; whereas at the beginning of our book [we treated] the description of the figure of the terrestrial globe with all its climes and its regions, and from it we ascend [...], to descend [again] from above to below. Therefore I arranged and set in order that which, in the description of the two gates that have passed [...], informing the students with a small, brief note — an opening and introduction concerning the spheres of the heavens (גלגלי שמים) and the stars — so that we should not [proceed further] before it be known to us [the nature of] the earth, and how many degrees or parasangs its measure, and its places and provinces, and — regarding the inhabitants of the world (יושבי חלד) — how many degrees they dwell along the length of the world between east and west, and how many degrees in the latitude of the world between [north] and south; for [none of this can be grasped] unless the little introduction from the science of astronomy (חכמת התכונה) be first known.

סימן נ"ה (Siman 55)

Proofs and evidences that the earth is spherical.

Know that the astronomers have ruled, concerning the form [of the earth], that it is spherical; and they did not reckon the great mountains and the deep valleys found in the world, because their magnitude is not to be counted for anything against the great size and mass of the body of the terrestrial globe — just as, if you were to affix a tiny [speck] to a ball, [that] point does not nullify the sphericity of the ball. And although we find, in the words of a few sages, that they held the earth to be flat and not spherical, and bring a proof for this from what we observe — that the sun [appears whole] at its rising on the horizon, [and] likewise at its setting, so that the sun is cut off from the terrestrial globe on a

straight line; whereas, were the earth spherical, it would be fitting that the figure of the sun's half should appear as an arc, in the manner of the shadowing of one sphere by another, as we see in the moon by the shining of the sun upon it, and as the moon appears at the time of its eclipse — [nevertheless] the science of astronomy has refuted this proof, and said: What we observe, that the [moon] appears in the figure of an arc — the sun too [would so appear] — is for this reason: that we are able to see both the moon and the sun on all sides of them, [over] the whole of their spherical [face]; [...] and likewise the sun in its [season], [when] it appears to us as an arc.

But this is only because the terrestrial globe is not seen by our eyes at a single glance — not even an eighth part of it — and therefore we cannot perceive by our sense [of sight] that the earth is spherical like a ball; rather, the earth appears to our eyes as though it were flat and not spherical, and for this reason [the horizon] cuts the sun, to our sight, on a straight line. And although it is established as certain that the earth is spherical, behold, this proof [of sphericity] is [grasped] by the intellect and not perceptible by the sense of sight. The essence of the matter [is that] the earth is round and spherical, as will be explained shortly with [several] proofs. Several proofs:

There is [reason] for you to know that the sphericity of the earth [is established] by the things we explained above at the head of the first gate, and it will be further explained to you later — that the earth together with the water, the two together, form one sphere; and the earth is exposed within the water over the surface of all its extremities, and over all of them the inhabited land spreads out, over the whole surface of the sphere all around — in such a way that even the surface of the terrestrial globe opposite the soles of our feet [the antipodes]: there too will be found habitation and people who walk there, and there are found great and mighty cities and many provinces full of human beings. And although most of the common folk of the earth deny the sphericity of the earth and refuse to believe [in the antipodes] —

> *[Boxed note / mnemonic]* — [saying:] How is it conceivable that [Reuven] and Shimon should stand on opposite sides [of the globe], this one above it and that one beneath it, and each of them stand upright, his head up and his feet down, as though each of them were hanging by the soles of the other's feet — and how does neither of them fall? And further, [that] the two [points] of the world-globe stand for us [like] the navel of the earth (טבור הארץ): Reuven at the eastern extremity and Shimon at the western extremity, both upright — how do Reuven and Shimon not fall?

Sign: Know that the sphericity of the earth is demonstrated by conclusive proofs,

and by a decisive proof that admits no [denial] — namely, that we observe of the whole [heaven] that, when in the north a southern star is hidden from us [and the reverse]; and so it is conversely. For when a man stands on the equator (קו השוה) he sees both poles (הצירים) level with his horizon; and when he moves away from the equator and ascends toward one of the poles [it rises], so that as [one goes] northward, for every 15 [ט"ו] parasangs the northern pole rises one degree — for every 15, 15 parasangs [one degree] — until he reaches the far north, where the pole stands at the very zenith of his head (קדקד ראשו), as will be further explained. From this the sphericity of the earth is proved by conclusive proofs, and likewise the sphericity of the sphere of the stars. [And I have set my mind] upon all the spheres round about, from north to south.

And the proof of the sphericity [of the earth] between east and west: this is [furnished] to us by the eclipse of the moon (לקוי לבנה). For every lunar eclipse occurs at one and the same instant in all the places of the world, for all the inhabitants of the earth. Now, when a lunar eclipse occurs, and two men are in two places — for instance, Reuven standing at the eastern extremity and Shimon standing at the navel of the earth (which is midway between the eastern extremity and the western extremity) — the time of the eclipse falls for Reuven at midnight and for Shimon at the beginning of the night, even though the eclipse is, for both of them and for the whole world, at one instant; [and thus at the time of the eclipse for Shimon it is several hours later].

And this is [proof of] the sphericity of the earth: for when it is the beginning of the night for one standing at the navel of the earth, at that very moment and instant it is midnight for those dwelling at the eastern extremity — since the sun precedes in its rising, and likewise in its setting, for those [to the east], and is later for those dwelling to the west. But had the earth been flat, the eclipse [would occur] in all places, for all the inhabitants of the earth, at one instant, and the easterner would not see the eclipse at a time earlier than the westerner. Since, then, the priority [in time] belongs to the easterner before the westerner, this is by reason of the sphericity of the earth. So it has been demonstrated to you, by the preceding proofs, that the earth is spherical in all its directions.

And you must know that we have no priority, nor any pretext, over the people whose feet are opposite the soles of our feet [our antipodes], to say that we are seated above upon the globe and they are seated below it — because every place where a man stands, there he is "above" upon the earth, and there is for him the

high point of the globe; and in this respect all the places of the world are equal. There is here no ground for any man to claim priority over his fellow, to say that he alone walks upright (קוממיות) while all [the rest] walk on the sides.

סימן נ"ו (Siman 56)

That many people encircled and went around the whole globe of the world, and returned and came [back] to the place from which they had set out.

While we are still speaking of the sphericity of the earth, [I saw fit to bring before] the world an account of a deed that happened in the year 1528 [?] by their reckoning, [which] was the year 5288 [?] by Creation [ה'אלפים רפ"ח [?] AM; 5288 − 3760 = 1528]. There was a man whose name was Sebastián del Cano [שבסטיאום די קאלבו [?] — Juan Sebastián Elcano [?]], a man of war, a commander of the army of the King of Spain, a great sage in the science of geography (גיאוגרפיה) — that is, in the measurement and knowledge of the places of the terrestrial globe. He set out from Biscay [ביסקיה [?]] — [a place] which is in Spain — and went down to the sea, and circled the whole western side of the continent of Africa; and from there he turned his face to the east, and went on traveling until he came to the lands of India (אינדיאה), which is the land of Hodu. There the people of that land attacked him, and his lieutenant was killed there, while he escaped in his ship together with four hundred men; and straightway the wind bore them along until he came to the far east and beyond it — at which place the soles of our feet [would be] opposite the feet of the people of his own country from which he had set out.

There he resolved in his heart not to [turn] his course westward, but only to see whether he could encircle the whole globe of the earth. Therefore he continued to sail on in his ship still further toward the east, and traveled on until he came near [the New World] (whose location will be explained later, in siman 73 [בסי' ע"ג]). He rounded it, keeping it to his left, and always kept his face toward the east; [he] did not turn his face westward until his return to his resting-place, to his great city Seville (סיביליה — Sevilla), which is in Spain. And a tablet was made for him bearing the figure of a globe, on which was written (as though the globe were speaking to him): "You are the first who encircled me" [cf. the Elcano device, *Primus circumdedisti me*].

The author of *Me'or Enayim* [Azariah de' Rossi], in chapter 118, also mentioned this briefly; and a deed just like this one itself — that a certain man from England [מ-ענגעלאנד = "from England" [?]], a captain, named Francisco Drake [פרנציסקי דרהיקו — Francis Drake], in the year 1576 [אלף תקע"ו] by their reckoning, which was the year 5337 [ה' אלפים של"ז] by Creation [5337 − 3760 = 1577].

סימן נ"ז (Siman 57)

That the earth stands at the very center of the sphere of the zodiac (גלגל המזלות), like a point within the circle.

The earth stands within the very center of the sphere of the zodiac, even though [it is but a tiny point]. As for the poles of the world (קוטבי העולם) and the axes of the zodiac (צירי המזלות) — this was [demonstrated] above at more than [...] degrees, in siman 37 [?]. Therefore [know] that the earth stands at the center of the sphere of the zodiac, and its center is the center of the ninth sphere [...], the center of the sphere of the zodiac itself; for it has already been explained above [...] that all these three great circles [of the globe] all stand upon the center of the world.

Therefore know that its center — the earth — does not incline from the extremities by more than [a single point]: not to the east and not to the west, not to the [north] and not to the south, not up and not down. And the proof of this is: that in every place of the world where one stands, he sees half of the sphere of the zodiac in its fullness; whereas, had the earth inclined toward the extremities, the man standing upon it would not see [exactly] half of the heavens, and the one opposite him would see more than his half. [Since everyone sees exactly half,] this is clear testimony and evidence that the earth is at the center of the sphere of the zodiac. Amen.

סימן נ"ח (Siman 58)

That the terrestrial globe, by reason of its great smallness, has no proportion or measure — [being] as if imperceptible to the sight of our eyes against the vast breadth of the sphere of the zodiac.

From the principle we have stated, it necessarily follows that the whole terrestrial globe is reckoned as [nothing] against the vast breadth of the sphere of the stars. For [were] the body of the earth reckoned as having some [appreciable] measure, and should it enter our mind [that the earth had a size] in proportion to the sphere of the zodiac, then not all the inhabitants of the earth would be able to see, in every place, half of the heavens; for of necessity each of the inhabitants of the world, in every place, would see only less than half of the circle of the zodiac — as you will see in the figure below, in which the [outer] circle [הקטון [?] — "small"; but context requires the larger circle] represents the sphere of the zodiac, and the inner one the circle of [the earth],

Diagram. A large circle (representing the sphere of the zodiac) with a small circle drawn near its center (representing the terrestrial globe). Three horizontal parallel chords cross the large circle — horizon-lines at different positions — one passing through the small circle. Points are lettered at the ends of the chords / on the circumference. The figure illustrates that from the negligibly small earth an observer sees exactly half of the great circle.

- א (lower center): the observer's position / center of the earth
- ד (upper area): a point on the edge of the earth / horizon-line terminus [cross-referenced in the text: "one standing at point ד," "from point א to point ד"]
- ה [?] (upper right): terminus of a horizon-chord
- ו [?] (upper left): terminus of a horizon-chord
- ב [?] (lower right): terminus of a horizon-chord
- נ [?] (lower left): terminus of a horizon-chord

[More than two labels uncertain]

the earth; and the line divides the circle of the zodiac into two equal halves, thus. One standing at point ד — wherever he be — sees only what is above this line, which is less than half of the circle. (For it is not fitting to say that one standing upon the surface of the earth at point ד would see the surface of the earth below this line, as one standing on a mountain sees from opposite the mountain and downward — that is impossible; for even at 15 [ט"ו] parasangs he would see only one degree [rise], [and so many] degrees in the sphere.) And because we always see, in every place, whole [complete] zodiacal signs, and because the horizon — the circle of vision from one's standing-place on the earth — is exactly as though we were standing at the very center of the terrestrial globe, upon its center at point א; and the line that issues to us [from] the center of the earth from above, reckoned from point א to point ד, which passes over the edge of the terrestrial globe — even though its measure is a line of [thousands of] parasangs [?] — for our position it is reckoned as nothing. And this line — that of the whole terrestrial globe in its entirety — is reckoned as merely a point within the [great] circle. And this is by reason of the great distance and remoteness of the sphere of the zodiac; for the very diameter (קוטר) that issues to us from [the center of] the earth indicates to us a [mere] proportion against the eighth sphere (גלגל השמיני), [comparable] to [a small object against a great mass] — for the investigators have posited that [each] of the fixed stars (כוכבי שבת), its body is many times greater than the body of the earth, as has been [reported] to us [in the writings], [by] a word or a [received tradition].

Know that many of the sages have expounded and inquired into the vast breadth of the eighth sphere; but to this day, for all their great effort and inquiry, it has not become known to them as it ought, according to precise and correct reckoning. R. Yitzchak Yisraeli [Isaac Israeli, in *Yesod Olam*] wrote, in chapter 8 of the second [treatise], that some of the sages posited in their researches that the length [of the circumference] of the world [the eighth sphere] is more than [what corresponds to] thirty mil [שלשים מילין [?]] per day [...]; and this — how much would it be? — according to the circumference of the circle, a journey of 44,000 [מ"ד אלף [?]] years, which are [...] ten thousand times a thousand and [...] thousand [numerals not legibly recoverable — [?]] days, and its number, in mil, is [481? תפ"א [?]] thousand times a thousand, and eight hundred thousand [mil]; so that one finds that every star of the eighth sphere standing on the straight line [the equator] or near it revolves, by the revolution of the eighth sphere, in each and every hour, twenty thousand times a thousand and [...] a thousand mil [figures uncertain — [?]] — even though it appears to us [that its motion is like] the [distance] of the eye [i.e. barely perceptible], [as it were,] by the science of [reckoning]. And this reckoning is clear and easy for those who know the science of number and measure. The investigators went even further, and wrote more than double this figure; but I have not found among them one who proves his reckoning.

סימן נ"ט (Siman 59)

That every line of the heavenly circle above — they are all inscribed, conceptually [in the intellect], upon the terrestrial globe below.

Since the earth is spherical and stands at the very center of the ninth sphere, and also [at] the center of the sphere of the zodiac, as [stated] above, it follows from this that all the circles of the heavens above are engraved, conceptually [in the intellect], after the likeness of those [circles] which are in the spheres — circles just as there are upon the surface of the terrestrial globe below. And this [means]: that the equatorial circle (עגול משוה היום), which is like the middle of the heavens between the two poles (הצירים), inscribes and marks out for us a line...

each one at the center of the earth's globe, which revolves and is called by the same name as the circle that stands directly above it in the heavens. It too is like the circle of the equator (עגול משוה היום); and likewise the other circles of the earth that correspond to the circles of the heavens — such as the circle of the zodiac (עגול המזלות), the circles of Cancer and Capricorn [the tropics], the circles of the nadir[?] and of the meridian[?] — each and every one is called by its own name, by the name of its counterpart standing directly above it. And the benefit

that comes to us from this is that, by means of a place's position, all the dwellers of the earth are made known to us: those who inhabit the world, under whatever circle or sign they dwell; and each and every place of all the world's inhabitants — how far it lies along the length of the world [longitude] and how far along its breadth [latitude]. By its sign we come to know the nature of each and every land as to cold and heat, as to the length or shortness of its days, as to the earliness or lateness and the [rising][?] of the sun for the world's inhabitants, and many other matters besides these.

סימן ס (§60)

That the earth's globe too is divided into 360 degrees in length [longitude] and also in breadth [latitude]; and at what place this reckoning begins.

According to what we have just explained — that all the circles of the heavens above are inscribed upon the surface of the earth's globe below — you should now understand the following. Just as the astronomers divided each of the great celestial circles above, [as measured] upon the center of the earth, into 360 degrees (as above in §36 [ל"ו]), so too they divided every line encircling the earth's globe and passing through its center into 360 degrees, and each degree into 60 minutes [דקים], along the equator[?], conceptually inscribed, as it were, upon the surface and center of the earth's globe below. This runs from west to east, and is what is called the "length of the world" [longitude], as will be explained; and it is divided into 360 degrees.

We must now determine where the point or place is that holds the privilege [משפט הבכורה] of being the starting point from which the counting of the 360 degrees of the world's longitude begins. Know, then, that because of the earth's sphericity, no beginning or end can be discerned upon it [naturally]; rather, by convention, one must select for oneself some known place or point upon which to agree, to set it as the head from which to begin the reckoning. Since the earth's globe faces the heavens[?] — as [Ptolemy][?] said in the treatise... the astronomers[?]... found that the length of the inhabited world, from the edge of the western Ocean [אוקינוס המערבי] to the shore of the eastern Ocean at the far end of the East, is 180 degrees, which is half the earth's globe (as will be explained shortly). Accordingly there are here two lines — the eastern edge and the western edge — that hold precedence over all other places of the world. And because these two mentioned places are two [candidates] from which to begin, the ancient sages nonetheless agreed to begin this reckoning from the edge of the western Ocean, since most of the lands adjacent to it are more inhabited than the lands at the eastern edge, and also because the ancients [Ptolemy?][?] were nearer to the

shore of the western Ocean… The starting point[?] is the place of the [Fortunate Isles / a known headland][?], running along the coast of [Cape Verde?][?] and continuing along the coast of [Porto / the Portuguese coast][?]… by way of… [Portugal — פורטוגל]… [The specific coastal toponyms of the prime-meridian line are badly garbled in the print — [?].]

[before Ralbag[?]] it fills[?] Africa, and running southward to the south pole [קוטב הדרומי] (places that will be explained further on). Along it runs, as it were, in the dark, across the breadth of the world, from pole to pole. It is called the "boundary line" [קו הגבול] or the "western line," for it forms the boundary and terminus at the western extremity, from the midpoint of which the boundary line begins and the equator[?] line runs along the length of the world, upon which the 360 degrees are marked — that is, from this boundary line and the numbering of the 360 degrees. From this line the count issues at the western edge, running eastward to the end of the inhabited world at the shore of the eastern Ocean, which is 180 degrees, half the globe of the world… and this line continues onward from the western edge yet farther, beneath the earth relative to our position, until it circles back to the whole place from which it began to issue — which is another 180 degrees, so that together they make 360 degrees.

But you should know that the tradition of the sages who delved deeply and investigated the science of measurement [geodesy] moved the boundary fixed by the earlier authorities somewhat farther, into the Ocean toward the west, [by] ten degrees [עשרה מעלות] according to the divisions of the equator line from which the numbering of the 360 degrees begins, and so forth, as will be explained further at the head of the section, God willing.

And you should further know that, just as there is a distinction between longitude and latitude of the firmament (as above, §45 [מ"ה]), so too there is this very same distinction upon the earth's globe. Namely, they divided the circle surrounding the earth's globe into four quarters, each quarter holding 90 degrees, which together add up to 360. This is in the manner explained above in §45, and it will be mentioned again below, God willing.

סימן ס"א (§61)

How the ancients knew, when they measured the line of the length [longitude] of the dry land, that it equals the line of half the earth's globe, which is 180 degrees.

We have already explained just above that the length of the inhabited world, from the edge of the shore of the western Ocean to the shore of the eastern

Ocean, is half the earth's globe — 180 degrees, no more and no less. You may ask: from where did the ancients know this measure for their reckoning, that the [breadth of the] sea is neither less nor more? So know that the ancient sages appointed for themselves messengers — trustworthy, expert men who understood these matters — and at times they sent some of them to the far East and [some] to the far West, to the edge of the West, and instructed them to observe and note carefully, each in his place, the time of the moon's entering into eclipse on a given day. The western group observed and saw that the moon began to enter eclipse at the beginning of Friday night, for example, while the eastern group observed in their place… that at daybreak the moon was fully extinguished in its total eclipse. (It is already known that the moon's eclipse [is visible] to all the world in a single instant; nevertheless, between the vantage of the westerners and that of the easterners there was a difference of twelve hours [י"ב שעה].) From this they concluded that the inhabited world extends in length by half the world's globe, which is 180 degrees. For [with respect to] two men standing opposite one another, the earth's globe is interposed between them, so that the beginning of night for one is the beginning of day for the other, as explained above in Section 2, §46 [מ"ו].

סימן ס"ב (§62)

How many parasangs upon the earth's globe are to be reckoned against one part of the 360 parts of the sphere above.

Even though, according to what has been mentioned and explained above concerning the vast distance of the zodiac sphere relative to the dimension of the earth's globe — [the earth being] like a mere point to a compass[?] — even were you to lay out thousands upon thousands [i.e. millions] of parasangs, they would not suffice, in the astronomers' reckoning, for even a single one of the 360 degrees of the sphere (as above, §35[?] [ל"ה]) — nonetheless, know that the investigators reached [a measure] in this matter regarding the breadth of the zodiac sphere; and even were its dimension a thousand-thousand times larger still, and were the world's [measure] such, this did not deprive them of, nor prevent them from, investigating and finding [how many] parasangs below upon the earth are to be reckoned against one part of the 360.

Upon the earth's globe the reckoning of fifteen[?] parasangs [ט"ו — see note] per one degree does not apply to them [i.e. to the latitude circles], unlike the… longitude lines that run from west to east, but only on the equator [קו השוה] alone and nothing else. For although, with respect to the reckoning of determining the longitudes of the countries, all the longitude lines are each counted as 360

degrees, the degrees [on the higher-latitude lines] are smaller — because the closer a longitude line lies to the axis [pole], the smaller becomes the measure of a parasang. This you can perceive by the senses: that the circle of Cancer [the summer tropic] is smaller than the equatorial circle, and the circle of Capricorn is its counterpart, being smaller still than the circle of Cancer; so too the 360 parts of the line of the Cancer circle, and the parts of the line of the Capricorn circle, are smaller than the 360 parts of the line of the equatorial circle.

סימן ס"ג (§63)

The measure of the line surrounding the earth's globe, and how many days and years a person needs in order to circle the globe.

From the general principle we have mentioned — that the whole earth's globe [is such that] each degree above corresponds to fifteen[?] parasangs [ט"ו] below — it follows that all 360 parts of the sphere above are 360 times fifteen parasangs below, whose sum comes to five thousand four hundred parasangs [5,400 — חמשת אלפים וארבע מאות]. Accordingly, since by the nature of the people of our land an average man's journey is five parasangs per day, the time to travel around this encircling line, from end to end, would be a journey of one thousand and eighty days [1,080 — אלף ושמונים יום], which is three years less sixteen and a half days [ט"ז יום וחצי]. This is somewhat more than the words of our Sages of blessed memory, whose plain sense is that the measure of the earth is a journey of five hundred years [ת"ק שנה] — for in matters of astronomy and the measure of the earth, the words of the Sages are one matter and the words of the astronomers another, of which more will be said below, near the conclusion of the book, God willing.

Know too, and be assured, that according to the view of the author of the *Me'or* [Ba'al HaMaor?][?]... the measure of the earth's globe is close to the aforesaid figure — as is the view of one who was... [when] Rabbah[?] said, "The world is six thousand parasangs" [Aramaic: שיתא אלפי פרסי הוי עלמא] (Pesachim 94a); and in any case we know and have seen that Rabbah's tradition was... and is very close to the reckoning of the investigators. So too according to ch. 5 of the *Laws of Oaths* of the Rambam[?] of blessed memory (and his Introduction to Seder Zera'im[?]), the measure of the earth's globe, its circumference, is twenty-four thousand mil [כ"ד אלפי מיל], which is six thousand parasangs — [agreeing] with Rabbah's tradition. See the book *Me'or Enayim*, ch. 29[?] [פ' כ"ט], fol....[?].

סימן ס"ד (64§)

Refutation of the view of the ancients [printed החקרמוני', for הקדמונים][?] in what they said, that half the earth's globe is submerged in water.

[This siman refutes the claim] that half the earth's globe is exposed while half is sunk and submerged in water — as you find in the sage [Ibn Ezra — ראב"ע][?] (and in his own words[?]) in his comment on the verse "for He founded it upon the seas" (*Tehillim* 24:2); and likewise the view of the great astronomer R. Avraham bar Ḥiyya, author of *Tzurat HaAretz*; and so too you find in the sage R. [Isaac] Israeli [*Yesod Olam*], part one, treatise..., and *Yesod Olam*... and in many other places there in his book, where upon this premise he laid down many foundations and built many structures upon it, as will be explained further at the end of part two, §140[?] [ק"ם][?], part..., section 8[?]; and see that this was his view, as the author of *Me'or Enayim* noted precisely upon it, in ch. 61[?] [פ' ס"א] — [the view of] all the ancients, all of them.

In this matter they were, as it were, [mistaken and] in error. For, as of a little more than a few years ago and up to now, seafarers — the expert envoys of France, Spain, and Portugal [פורטוגאל] — went down to explore the [Ocean-]sea, [a region] known to them only by chance and not by the fixed measures of every[?] region of the world's globe; and they found inhabitants — some of them upon dry land, some upon the islands of the sea, some in the upper part, some in the lower part directly beneath the soles of our feet — and this is the New World, which they call *Nieuwe Welt* / *Mundus Novus* [מונדא נובא / ניאו-וועלט][?], where a broad and open land is settled: a great region, close to two-thirds of the world in which we ourselves dwell, and all of it full of human beings, as will be explained shortly. And even though we find in the fifth chapter of *Pirkei d'Rabbi Eliezer* the statement that the earth stands upon the depths like a ship sunk in the heart of the sea, and also in the chapter "..."[?] of *[Bereishis] Rabbah*[?] they said that the world is like a ball and like a bowl — and accordingly one said, by what appears [to be its plain sense], that the world's globe is submerged in water, as is the view of many of the sages: [Ibn Ezra — רחב"ע][?], Radak [R. David Kimchi], R. Avraham bar [Ḥiyya][?], and the aforementioned Israeli [Isaac Israeli] — nonetheless, the revealed, well-known experience, plain to the eyes, contradicts [this]. For "for He founded it upon the seas" is to be understood as "upon the rivers and seas," like "By the rivers of Babylon" (*Tehillim* 137:1). And as for the words of our Sages of blessed memory, there is no great cause to wonder, for in many places, in matters of astronomy and the measure of the earth, their words are sealed and obscure;

and this matter he mentioned by way of example, and..., and at the conclusion of this our book it will be disclosed in a brief note in the aforementioned... — a great matter, to take to heart concerning things in the words of our Sages of blessed memory that are contrary to the astronomy revealed to our eyes, so as to reconcile them somewhat... lest they conflict with what is well established.

סימן ס"ה (§65)

Whether the earth stands upon the water, or the water stands upon the earth.

Since it has already been clarified that all the seas together with the dry land form one globe [ח"א — a single unit][?], there is room here to be in doubt and to ask: does the earth stand upon the water, or does the water stand upon the earth, [the earth] covering it? At first inspection it appears that the water stands upon the earth; and in truth this is the essential point[?], because all the waters, by clear proofs, are the smallest fraction of a fraction [מיעוטא דמיעוטא] compared to the earth's globe. For if the whole [surface] were left as water, as though the waters hovered over and covered the entire earth's globe; and were one to posit further that in every single place throughout the whole world one would find the depths of the waters — [even so, as will be explained in Section ..., chapter ..., God willing]...

and the thickness of the earth [to its center], according to the aforesaid reckoning, is approximately nine [thousand][?] mil[?] [תשע ... מ(י)לות]; [in a treatise][?] it will be [shown] that the measure of the water against the thickness of the globe is a fraction of a fraction of it. Take an illustration of this: that the pulp of an apple [שיעור עצמות התפוח] holds about eight times[?] the measure of its thin peel — and all the more so for a large, broad globe (for the larger the globe, the smaller becomes the measure of its peel relative to its body!). All these things are easy for those versed in the science of measurement, and there is no need here to elaborate the explanation of their reckoning, for it is not fitting to intermingle the matters. From the aforesaid it would appear at first inspection that, on account of its great size, [the earth] is the essential thing and the water is negligible — canceled, as it were — so that it would appear fitting for us to say that the water stands upon the earth.

However, after deeper inspection the opposite appears to us, and we say that the earth stands upon [the waters]. For if the whole earth's globe were entirely dust within, or were solid[?] throughout, it would not be filled with water even to an eighth part in proportion to the measure of the earth's globe. But according to

reason it appears to us to be the opposite: that the whole interior of the earth's globe is filled with water. This is why in no level place[?] anywhere in the world will you find fifty or a hundred cubits [of depth] without water being found there — for the waters press and well up and gush from within all the soil of the ground. So too we find, and see daily, that places in the mountains split open [in earthquakes], and at times… water flows out and issues forth like…, and rivers form that never existed before. From all of this it appears, to a first view, and it is near to believe — and it is the judgment of nature — that the interior of the earth's globe is filled with water. Accordingly we would say that the majority is water and the water is primary, and the earth stands upon the water. And perhaps to this the Psalmist alluded in "[Who] spreads out the earth upon the waters" (*Tehillim* 136:6). Some support for this I found in the book *Maaseh Hashem* by the sage R. Eliezer Ashkenazi, in ch. …[?] of his book, on the verse "Let there be a firmament in the midst [of the waters]" [*Bereishis* 1:6]: that before "Let there be a firmament," the earth was a solid mass, so that if a man were to bore down to its center he would find no water there; but when the Creator decreed "Let there be a firmament in the midst of the waters," behold, [the earth] filled with water, and so on — such that this is [the meaning of] "Let there be a firmament": that the whole earth is [made] like a mixture[?], so that a firmament be enclosed within the water. Thus far his words. And in my view, "[Who] spreads out the earth" is also called "heaven," as it says accordingly, "And God called the firmament heaven" [*Bereishis* 1:8]. One may also say that what accords with the words of our Sages of blessed memory in their saying, "Upon what does the earth stand? Upon the water," is that their words agree with what we have chosen, as above — until I hear what my teachers will say.

סימן ס"ו (§66)

Refutation of the view of the ancients who said that, opposite[?] the equator [קו הישר], there is no habitation because of the excessive heat, and near the northern circle there is no habitation [because of cold]; and an explanation of the seven climes [אקלימים / *climata*].

Know that the ancients — chief among them Ptolemy [תלמי, printed garbled][?] and those who walk in his footsteps — judged that beneath the equator, and on both its sides, north and south, along the full breadth of the zones of the zodiac — namely, the entire band that lies between the circles of Cancer and Capricorn (as will be explained at the head of Section 5, God willing, regarding the breadth of the band between the two circles, which holds close to 40[?] degrees [מ"ם —

likely 47/48, uncertain], as has been explained) — it cannot be inhabited [because of heat].

…[uninhabited] by dwellers, because of the excessive heat… the [torrid] zone[?], which in the Latin tongue they call *Torrida* [טוריד"ל — Zona Torrida][?]…, the zones being scorched, as it were, in their view — that everything there is burned and dried up. And so wrote Radak[?] [תרד"ק][?]… Accordingly, the beginning of the boundary of the habitable band runs from the circle of Cancer northward. About 24 degrees [כ"ד מעל'] from the equator to the north, the whole tract which is [from] the [circle of] Cancer toward the [south?][?] — throughout the whole quadrant[?] — they reckoned, and the ancients named it, as uninhabited; except that the ancients set the beginning of the habitable band from the line of the Cancer circle, [and] a further ten degrees [עשר מעלות] more toward the north…, so that they excluded everything that [lies] within the zones of the zodiac up to [the point where] everything is scorched and burned at the season of the summer solstice [תקופת תמוז]. Likewise the ancients [held] that from the circle of Cancer northward, and below it down to the [arctic?] line, [the region] is found devoid of habitation because of the excessive cold. Accordingly, habitation, in the reckoning of the ancients, was only about a quarter of the globe.

[From] the 24th degree from the equator to the northern circle [עגול הצפוני], which is [some][?] degrees — which, by the reckoning of fifteen[?] parasangs [ט"ו] per one degree, is [so many] parasangs — this breadth alone the ancients' investigation reckoned [as habitable]. They divided this mentioned breadth into seven parts and called each part an *aqlim* [clime] — an Arabic word; in our tongue it is called…, called after the biblical expression "the three seasons[?]" (*Yehoshua*[?]…, [and] "…the earth," *Tehillim* 48[?]), as Radak[?] wrote…

And these are the seven mentioned climes, each of them [extending] from the western place to the eastern edge, according to the length of the upper globe; and they are 180 degrees in length. And for fuller clarification… — [here is] this figure:

Diagram. A circle representing the earth's globe (or the celestial sphere) shown in cross-section, with a set of horizontal parallel lines (chords) drawn across it, representing the several latitude-circles / the seven climes as parallel bands. The accompanying text identifies the lines by point-letters: the earth sits at the center like a point[?]; line "ג–ח"[?] is the equator [קו השוה]; line "ה–(ו/י)"[?] is [the Cancer] circle; line "ו–ח"[?] is the northern circle [עגול הצפוני]; and from it the seven climes are marked. Readable Hebrew labels around/within the circle:

- ב (top of the circle)
- א (upper interior, below ב)
- ה (left side, adjacent to a horizontal line; a vertical word beside it — "קו השוה"/"משוה"?[?])
- ו (far left edge)[?]
- ג (lower-left)
- ד (bottom)
- פ [or צ][?] (lower-center)

[More than two labels are uncertain and the point-line correspondences (ח–ג, ה–ו, ו–ח) cannot be fully matched to visible letters — figure flagged as a]

Because every clime nearer the north pole[?] [צד קוטב הצפוני] has its length-line shorter — as you will see in the figure, each one being shorter than the [preceding] line…, at any rate…, for the sake of knowing and determining, for all the places of the earth, how many degrees each lies along the length of the world [longitude] and how much along its breadth [latitude], they divided all the climes — whether long or short — each one [into 360?]; each of them being 180 degrees along its length, as will be further explained [in §69?]. And as for their names, I have already written just above that all seven together have a breadth of 50[?] degrees [מ"נ — uncertain]. The ancients recorded some of the names of the countries in each and every clime, and also the length of the longest day in each of them; but we have no need of these in this our book, for it will suffice for [our purpose] the measure of the divisions of the length and breadth of the globe, as [explained]. The extent of our discussion at this point is [confined to] their boundaries. The ancients set the earlier [seven climes] for the inhabited region alone, and reckoned the rest as wilderness and desolation, as they said, that no man passed through them, and the foot of no beast trod them — neither on the southern side, because of the excessive heat, nor on the northern side, because of the excessive cold.

However, [thanks to] the sages, the vessels[?] of their investigations, particularly in recent times — from some years ago until now — it has become known to us from them that trade has already been borne widely over the face of the earth [חלד], and settlement has spread even beneath the full breadth of the zones of the zodiac. Even in our own time, ships set out year by year (from Germany [אשכנז], from France [צרפת], from [Amsterdam?][?], and from Portugal [פורטוגאל]), traveling by way of the Indies [אבדיא"ם — India?][?] (Calicut [לקלקוט][?])…, [to] the inhabited [lands] that lie toward the East; and along this route they encircle and go around the region of Africa [אפריקא], which is like a pointed [triangle] set

within the sea, and they pass around it in such a shape…, and all return to their place like…, and go back and return to their land. They must pass beneath the full breadth of the zones of the zodiac four times in going and twice in returning, such that in this journey of theirs the sun stands overhead… four times… — and [settlement and habitation] are found there, [directly] beneath…, four times… as though appearing face to face[?]. Concerning the route of this journey — as [also] the countries mentioned that they travel to — likewise, year by year, they go by way of the west of the whole world…, and go to [the region of] part 176[?] [פ' וקע"ו][?], where the majority of the countries are settled, beneath the full breadth of the zones of the zodiac, as will be explained further [in §75?]; and it has been disclosed to us [that there are] many settled countries…

סימן ס"ז (67§)

The reason the ancients divided the inhabited world, and [assigned it] to seven climes.

Know that when the ancients divided the inhabited world into seven climes, their main intention was to know in which clime each and every country, city, and town lies, and also to know the measure of the longest day of each and every clime. But I do not know why they fixed specifically seven climes; for it would readily occur to us [lit. "fill our heart"] to fix more climes than seven — indeed, not merely seven but even seventy, and seven[?] could be arrived at — since it is an easy matter to know, for each clime, or at each degree, the line of the locations of the countries…

שער ג [Gate 3] — continued

[Continuation of 67§ / סימן ס"ז — the divisions of the inhabited world]

the countries and the cities, and likewise the length of the daytime in each and every place, as before — as [stated] in the sixth discourse, in §145 [בס' קמ"ה (?)]. For this reason we will not expand on an account of the seven climes, nor have we assigned them as markers for the locations of countries, since it suffices for us to know the measure of the line of longitude and the measure of the line of latitude of the terrestrial globe, and from these to know its settled regions — as all this will be explained further on.

You should also know that the ancient sages divided the whole aforementioned inhabited world — that is, the seven climes — into three parts. And after many years, up to the present, they went on adding to the regions of the world, addition after addition, until in our own times they have reckoned and divided the globe into eight parts. These are their names. The inhabited region of the seven aforementioned climes they divided into three parts, namely (Asia [אסיה (?)], Africa [אפריקא], Europe [אירופי]); the New World they divided into two parts, namely (America [אמריקו] and Peru [פירוט = Peru (?)]) — that makes five; further, they took in a great part and called it ([נאבת ניכיניאס] = Nova Guinea / New Guinea (?)) — that makes six; and to these they added and marked the Northern World and the Southern World — that makes eight. And now, to detail them for you:

[68§] סימן ס"ח — The construction of the figures of the entire terrestrial globe, the seas together with the dry land, in all eight aforementioned parts, in general outline

The author says: Before I speak of the particulars of the eight parts of the world — so that these matters not be to the students like a dream without an interpretation — I saw fit to sketch broadly the whole plan of the figures of the entire terrestrial globe [together with its seas (?)], in general. And because it is impossible to depict a globe upon a flat surface properly, the opinions of the researchers here have multiplied, and they have depicted it in various aspects and forms [שונות] and the like; these are [their several] ways of representing the terrestrial globe upon differing flat aspects. But to make it easier for the students, I chose one of them [and thereby] discharged the obligation of them all [i.e. it serves in place of all], as [being] clearer and easier to explain to the students: to draw it upon this surface as two flat circles. It will appear to your eyes as though an apple — or the globe — were cut in two from top to bottom, that is, [drawing] from the northern pole down to the southern pole (an easy way), and likewise easily from west [to east], into two equal parts, [the marking running] up to 180 degrees [180 = ק"פ] for each. And it will seem to you as though the two halves of the globe, or of the apple, were drawn out and flattened until each is like a surface [that is not raised]; yet nonetheless picture in your mind that each of the two flat circles is like a bowl, or like half a sphere.

so that in these two circles the aforementioned places will lie near [to one another (?)]… only in two circles… [and I have marked it] with symbols [וסמנים (?)] and dots — and this is enough.

And this making of the maps [charts] according to Ptolemy [כתובנייס = Ptolemaeus] is [called] "mapping the world," and in the Latin tongue *mappa mundi* [מחפת מונדי]. The making of the maps themselves I did not find transcribed within this book… (and whoever wishes to grasp the configuration of the world that [Ptolemy set down], let him look within a chart [קארט] on which it is depicted).

[69§] סימן ס"ט — An explanation of the two maps, with an account of some of their circles

The two maps are required… for the globe [and its eight parts], as will be explained. Now it has already been explained above, in chapter 29 [בפרק כ"ט], that all the circles of the heavens above are inscribed — intellectually — upon the face of the earth below. Therefore I saw fit to mark for you, upon this surface that stands in place of the terrestrial globe, the more necessary circles: [some] extending eastward, and [a line] drawn from north to south. And although the five lines mentioned are [drawn as] simple lines, nonetheless know that each and every line encircles [the whole globe]. …[the line] whose opposite is the Tropic of Cancer [עגול סרטן]… This line is divided and marked off every ten degrees [and numbered 10, 20…] [14 (?) — see note] until the completion of 360 degrees [ש"ם / 360 / 340 = ש"ס (?)], and it is called "the long line," as above in §60 [כנ"ל בסי' ס']. …And in each quarter are marked ninety degrees [90 = צ'], corresponding to what was explained to you above in §35 [בסי' ל"ה] concerning the lines called lines of latitude [קוי הרוחב], by which one measures and estimates, in each and every place, how many degrees it lies between north and south — which is reckoned as the latitude of the world.

And now, once the names and locations of the countries and cities are marked upon the globe, you will easily be able to see plainly with your own eyes, without error, this reckoning: to survey the many places, and the longitudes of a country — that is, how far each of them lies in the longitude of the world between east and west, and how far it lies in the latitude of the world from the equator [קו השוה] toward the northern side. For example, Jerusalem [ירושלים]: you will find it in the latitude of the world, toward the northern pole, [at] 32 degrees [= ל"ב 32]…

[70§] סי' ע' — Depicting the terrestrial globe in another manner — for it more closely resembles the solid, rounded globe [כדור המעוקב (?) / המעוקם] — to complete [the matter]

[Regarding] this work, I saw fit to inform the reader that some of the geographers among the later, more recent sages [depict] the terrestrial globe in a manner different from the foregoing… And the depiction begins as though one cut the globe in two: it starts from opposite the northern pole and runs through the center of the globe along with the southern-pole axis… upon a sheet [drawn] in such a way that you fill in the two poles on two discs [לוחות]… [In] the flat-circle [method] the ancient sages already made use, since through it three parts of the circle are represented [as] before — from the western edge to the eastern edge, which are [so-and-so] degrees, as above, and no more are needed. …[In the alternative method] the globe is divided differently, and this is how it is done: picture it as though the globe were cut in two, in every figure, upon the line of the equator [קו השוה]… on the northern [disc] you will find the disc [drawn] with its pole at the center within the circle, and likewise you make the southern [disc]… [the part] that is beneath the earth… resembling the solid, rounded globe [כדור המעוקב (?)]… and the circle of the Tropic of Cancer [עגול סרטן], and likewise the other circles of longitude [עגולי האורך]… [each] at an equal distance from the northern pole, truly like the circles of the solid globe, indeed like a sphere — for so it is seen plainly, as will be explained.

[71§] סי' ע"א — That the ancients divided the inhabited world into three parts, namely Asia, Africa, and Europe

Know that the ancients already divided all the inhabitants of the northern [inhabited world] in its entirety — that is, the seven climes — reasonably and with good sense into three unequal parts. The largest part of all is called Asia [אסי"אה]; the second, smaller than it, is called Africa [אפרי"קא]; and the third, the smallest of all, is called Europe [אירו"פי]. Now I will set out for you their bounds and borders, one against another — where they begin and where they end — all by clear and known markers; and the aforementioned figure will show plainly all the markers I mention. I will begin with the part upon which we dwell.

The first part is called Europe, after a certain woman named Europa [איפרופי (?)], daughter of the king of Phoenicia [פיניצ'אן = Phoenicia (?)], who reigned and was carried off across the whole land, until this whole part fell under her dominion, and she called it after her name Europa [חרו"פי / איפדופי]. …As for its situation,

bounds, and borders: know that its place is, as it were, on the northern and western side of the world's settled region, and it is encompassed and surrounded by seas on all sides — from the south, the west, and the north. For toward the south this part reaches the Great Sea called in their tongue *mare mediterraneo* [אמ"ריקי"ו דיטע"רא = Mediterraneo (?)] (its meaning: "the sea in the middle of the world"), which is the Mediterranean Sea [ים התיכון], running from Spain [ספר"ד] and passing across the face of most of Spain, France [וצרפת], Italy [איטלי"א], and all the land of Greece [ארץ יון], reaching as far as the Holy Land [ארץ הקדושה]. The length of this sea is some hundreds of parsangs, and its breadth now increases and now decreases, [varying by] some parsangs. This Great Sea divides the part of Europe from the part of Africa [אפרי"קא]. And the islands enclosed within the Great Sea… the ancient geographers reckoned and marked all the islands of this sea as belonging to the European part…

And to the north, this part stretches upward and upward until the northern circle [Arctic Circle], where the Northern Sea sets its bound. On the eastern side this part begins from the shore of the Western Ocean [ים אוקינוס המערבי = the Atlantic]; and by the two boundaries, the northern and the western, the geographers [assign] to it all the islands of the northern and western seas. …[As for] the first part, called [איד"על (?)], stretching from the south to the north and falling within the Northern Sea, called [סיביעק"ן (?)]; and the second, called [טאני"סן (?)], running from north to south…

The particular countries in the European part are, then, as follows [several names garbled]: the kingdom of Portugal [פורטג"אל], [that] of Spain [ספר"ד], [אספכל"ן (?)], Italy [איטלי"א], [פאלחקי"א (?)], Lithuania [ליט"א = Lithuania (?)], Muscovy [מהסק"וי = Muscovy], [ליפלתב"ד (?)], Bohemia [בהמיא"ת = Bohemia], Hungary [אונגריא"ה], Turkey [טורקי"אה], [מח"צין (?)], duchies [דוכיס"ם = duchies (?)], Constantinople [קוקסטאנטי"נא = Constantinople (?)], and every land of [ציונו'דחל"י מצל"יא / טאראנל"יאה (?)], Romania [רומאני"א], the great rivers [נהרות (?)], England [אבנלטיר"א = Angleterra / England (?)], Scotland [שאטלנד], [אושקולי"אה (?)], [מיהרק"ו / אינ"ה (?)], the land of Denmark [לאנד דעני'מרק], Sweden [סוויד"ן], [חרמידי"ן (?)] — together with the great islands within the aforementioned Great Sea, such as Candia [קנדס = Candia (?)], Corsica [קורסי"קה], Sardinia [סירדינ"ה], Sicily [סצי"ל"אס].

[Continuation of the first part — Europe's character] …[This part reaches only so far], and everything that runs and spreads out, its length extending toward the globe['s far side], its breadth going on diminishing, until the edge of this part reaches the Ocean [ים אוקינוס] on the southern side, where it has no breadth at all,

only a slight [tapering] line — a little only; and in its overall shape this part resembles a triangle, or a pointed [wedge]. Nonetheless, within this part are great and hidden countries and kingdoms, [too many] to number; and its particular regions are countless. Yet in all its shape [it tapers, etc.].

This part, the part of Europe, though it was settled many years after the two parts Asia [אסי"ה] and Africa [אפריק"ה], as will be explained, is smaller than [Asia]. Nevertheless know that it is a well-established land, and there are no wildernesses in it save a very little — apart from Muscovy [מאסקוו"א = Moscovia] and its surroundings — for otherwise no place would be found in it around which there is a day or two's journey uninhabited, since the whole part of Europe is settled with great and populous cities and with people dwelling [in them]. On this account there is no need to travel through it in deserts; [one travels] from nation to nation and from kingdom to another people, tranquil and secure. And the researchers wrote that the European part is more populous than the part of Africa. Now, in our own time, this part is called "the part of the Christians" [חלק הנוצרים (?)], since the [Christian] faith has spread throughout this whole part from end to end, except for Constantinople [קונסטנט' (?)]…

The second part is called Africa [אפרי"קא], and they say it is so named after the [word for] heat [חמה]; and likewise that [other] part is called Asia [אסי"ה]. This is not the place to expand upon it… [The name "Africa" is connected] with the portion of Ham [חלק חם], [written] with a *yod* and a *ḥet*… as our Sages [רז"ל] mentioned. …[Within this part are great kingdoms:] Egypt [מצרים], Cush [כו"ש], Barbary [כרבריא"ה = Barbaria], [עמי'ראס (?)], Ethiopia [אנטיופ"יא = Ethiopia], the kingdom of Sheba [מלכות סב"א], and yet others besides.

The part of Africa, of which we spoke — here all the ancients and the moderns agree in making it the third of the inhabited world in the seven climes. This part is larger than the European part, nearly double, but smaller than the part of Asia. Its bounds and borders: it is set and surrounded by seas on its four sides, being round. On the northern side it stretches and presses along the whole face of the shore of the Great Sea [the Mediterranean], from its beginning to its end, from below the right of Spain [ימין ספר"ד] as far as the coast of [סקלוסס (?)]; for along the whole length of the Great Sea — which is the boundary of the European part, only [on its] south, as above — the Great Sea [is Africa's northern bound]. …On the west it is bounded by the western Ocean [ים אוקינוס המערבי]; and [where] the whole [southern] part tapers, being surrounded by sea on all sides, [it forms] a point — like the point of the aforementioned Great Sea… as far as the interior [חוף (?)]… And this part is called by the moderns [נובה / סקדונ"וס (?)]…

The third part is Asia [אסי"אה]. Its bounds and borders: on the eastern side it begins from the end of the Great Sea, [running] along the shore of the Holy Land [ארץ הקדוש'] and from the Red Sea [ים סוף], and likewise from the two rivers, the Tigris [חדקל] and the Euphrates [פרת]... This part [extends] on every side; its corner to the east reaches the end of all inhabited land — that is, to the shore of the Eastern Ocean [ים אוקינוס המזרחי]; toward the south, to the shore of the Southern Ocean [ים אוקינוס הדרומי]; and to the north, to the northern circle. This part is more than double the two aforementioned parts, Europe and Africa. And this part was settled first, [as Scripture indicates concerning] the dwelling of Noah, according to what [is said]... [and according to] the view of Targum Onkelos [תרגום אונקלוס] and the view of the researchers, [namely] the mountains of Ararat / Kardu [הרי קרד"ו], in the second part [of the region] within our borders, which in my opinion are in the territories of [ארמכיאלת / Armenia (?)]. In this part was the Garden of Eden [גן עדן]; and here dwelt our forefathers Abraham, Isaac, and Jacob [אברהם יצחק ויעקב]; here [was given] our holy Torah; in this part stood our Holy Temple [בית מקדשינו]; and, as a general rule, most of the account of Creation, the deeds of the patriarchs, and the deeds of the Torah and the Prophets — all were in this part, which is the part of Asia. Only the events of Egypt [מעשה מצרים] were in the part of Africa; and of the European part we find nothing [recorded] in all the books of antiquity, save that in the prophecy of Obadiah [נבואות עובדיה] he mentions Tzarfat and Sefarad, as he says, "and the exiles of this host of the Children of Israel who are among the Canaanites as far as Tzarfat, and the exile of Jerusalem which is in Sefarad" [Ovadiah 1:20] — and these are the lands of France [פרנצ"יא] and the lands of Spain [ניא"ספ], as Rashi [רש"י] and Radak [רד"ק], of blessed memory, explained there.

In this part are found great matters, long and broad beyond measure; and from this [comes] the knowledge of the names of the great and hidden kingdoms found in this part — [too many] for most of them to be numbered. I will mention only some of them, the largest: [ארמכיא"ס / Armenia (?)], [ריס כד"יס / ארבכ"ם (?)], Persia [פרס = פר"ם], Media [ומד"י], [אחיכד"יאם (?)]; here is the great [Cathay (?)] — China [סינא = China], [יחפין (?)] — all mighty and very great kingdoms, and many others besides.

[72§] סימן ע"ב — That the sons of Noah — Shem, Ham, and Yefet — divided the three parts of the world among themselves

Those who write on this science say that Noah divided the three parts of the world among his three sons, Shem, [Ham], and Yefet — for his sons, all together [received their portions]… the part of Asia [אסי"ה] fell to Shem, the part of Africa [אפרי"קא] to Ham [ח"ם], and the part of Europe [ארו"פא] to Yefet. In my opinion [these authors have] rightly said what they said, for when you examine the genealogy of the sons of Noah you will find great support and hint for their words, since according to the plain sense of the verses before us…

[The sons of] Yefet [יפת] received by lot the part of Europe, which the sons of Yefet inherited: "Gomer and Magog and Madai and Yavan and Tuval and Meshech and Tiras; and the sons of Gomer: Ashkenaz and Riphath and Togarmah" [Bereishis 10:2–3]. All these names are the names of the countries [of Europe]… known [in that] each and every one [land] is called, or its city [named], after him — as you will find in the *Sefer Yosippon* of ben Gurion [ספר יוסיפון בן גוריון], according to what they cite; and likewise Don Isaac Abarbanel [דון יצחק אברבנאל] explained it, [in his account of] the names of the sons of Noah, [saying] that today these are the names of the countries in the European part. Gomer and Magog they wrote — following the later Yosippon [כיוסיפון האחרון] — that from them came [/ נוועטי'ס ונוט"י (?)]; and from Yavan [יון] came the Greeks [היוונים]; and Tuval [ותובל], they said, is Spain [ספר"ד] (so too wrote the *Sefer Yuchasin*, folio 139 [ספר יוחסין דף קל"ט]); and Tiras [ותירו"ס] is [תרגית"ה (?)]; Tuval [is also identified with] [אליומי'נאס (?)], that is, [טיטו] land; [and Meshech] with [כוסים נופרי / ליפרי' (?)]; Togarmah [תוגרמה] is Turkey [טורקיה = Turkey], [לודני' (?)] — all of which are in the European part.

And to the sons of Ham [בני חם] there fell by lot the part of Africa [אפריק"א], as it is said: "And the sons of Ham: Cush and Mitzrayim and Put and Canaan" [Bereishis 10:6]. All these are the names of countries called after them, and they need not be explained, for they are all well known… these being in the part of Africa. And to the sons of Shem there fell by lot the part of Asia [אס"יה]: "the sons of Shem: Elam" [and the rest — Bereishis 10:22]. All these are names of countries called after them and need explanation: [Elam] is the kingdom of Persia [מלכות פרס], as it says in Daniel, chapter [8]: "…in Shushan the capital, which is in the province of Elam" [Daniel 8:2]. And likewise Ashur [אשור], for [its royal city was] Nineveh [נינוה], which was called [after him] and remained the metropolis

[ומטרפולין = metropolis] of the kings of Assyria, as it is called in Kings [II], chapter 19 [במלכים ב' סי' י"ט]. Also the five Arams [חמש ארנות / ארמים]: Aram Naharaim [אר"ם נהר"ים], Aram Tzova [אר"ם צוב"ה], [and] Damascus [דמ"שק]; Aram Maacah [ארם מעכ"ה], Aram Beth-Rechob [אר"ם בית רחוב] — (all of which are named after Aram son of Shem son of Noah). All these are countries marked out and known in the part of Asia.

[73§] סימן ע"ג — The discovery of a New World, called America, in the year 5252 [5252 = ה' אלף רנ"ב AM; 5252 − 3760 = 1492 CE]

The writer says: Since… this that lies before us is [only] a few matters… [for the benefit of] one of our students, so that the readers — even those who go astray — [may profit by it], I saw fit to set down in it a little more [than the bare arrangement], in order to establish [the matter]… [and to make known to the reader] the parts and locations of the terrestrial globe upon which he dwells; and joined to this [is the fact] that [the study of] the parts and places of the terrestrial globe involves many devices and great and glorious wisdom, and [the earlier authorities] delved deeply into it, as will be explained to you further on.

[There was] a great philosopher [קלאומ'טי = Columbus / Christopher Columbus (?)] among them, [who came] before Ferdinand [ורדינגו'ם = Ferdinand] king of Spain [ספר"ד] and his wife Queen Isabella [איזכל = Isabella], and argued that — according to what the philosophers had already established — the earth is round [עגולה], and that, because of the earth's continual sphericity, [if one sailed] past the land of Portugal [פורטוג'אל] across the Ocean [אוקינום] from west [toward the east], there would be found yet another dry land to the west. And King Ferdinand [ורד'] sent him — [just] as he was — with wise men whom he assigned to him; and they went down to sea. The sea over them was surging and stormy, and an east wind drove them toward the southwest; and they went sailing on until, after a few days, they came to the New World — though its magnitude was not known to them, for they reckoned it only as islands of the sea. And this was in the year 1432 [recte 1492 — Hebrew reads 1432 = אלף תל"ב, but the paired year and §-heading fix it as 1492 = תצ"ב; see QA] by their reckoning, which was the year 5252 since Creation [1492 = 3760 − 5252 ;5252 = ה' אלפים רנ"ב].

(After [these] things) — later, some years [afterward], in the year 1438 [recte 1498 (?) — Hebrew reads אלף תל"ח; see QA] by their reckoning, which was the year 5258 [1498 = 3760 − 5258 ;(?) 5258 = ר?"ם / רנ"ח] — Ferdinand [ורדי'נגום] king of Spain sent to the aforementioned lord, a second [time], a man of

understanding and knowledge, a warrior from his youth, named Amerigo [אמיר"יקו = Amerigo Vespucci], a man [פול רע"נלי = Vespucci (?)], who had already sailed with Columbus [קלו'מכי = Columbus] as mentioned; and with him great ships, with men of valor and fierce, bitter-souled men, and their weapons of war. And they went down to sea and came to the New World a second time, and he sailed to America [אמיריק"ו], [journeying] into that land a distance of many days, and did there great and awesome deeds, and became a marvel and a byword in all the kingdoms of Europe [אר"ופי]. For this reason that whole land was called after his name, America [אמיריק"ו], to this day. For although Columbus [קלומב"י] preceded him, as mentioned, he nevertheless did not perform notable deeds as Amerigo did. And this part is the fourth part of the terrestrial globe.

(Further) — after all the aforementioned things, in the year 1516 [= אלף תקי"ו 1516] to the Christians, which was the year 5276 [3760 − 5276 ;(?) 5276 = רע"ו 1516 =] — Charles [קרלו'לו"ס = Carolus / Charles V] king of Spain sent great ships, a great multitude [ספינות גדולות עם רב — no "four"/ארבע on the tile; Stage-5], to the aforementioned land of America [אמריק"א], and they captured there a great part of [those lands], and named that country [סטטני"א (?)]… New Spain [ספר"ד חדשה = Nueva España]. And there was found a land [סתיה (?)] lying in the latitude of the world, beneath the Tropic of Cancer [עגול סרטן], near the equator [near 34 degrees — 34 = ל"ד (?)], and in the longitude of the world from the western edge [at] 280 degrees [280 = ר"פ (?)], spreading and widening in every direction, as reported… about a hundred parsangs by a hundred parsangs, roughly. This country is a well-settled land, good and broad; and great wealth abounds there… among the sands on the banks of the rivers [נהרות (?)], fine pearls [מרגליות טובות] too are found there in abundance.

When Francisco [פרונטש"קו = Francisco / Francis I (?)] king of France [מלך צרפת] heard of all the aforementioned things, he too sent his ships with men of valor to that land, and they too captured there a great part of the land [סתיא (?)], and named it [פרחב"ני = New France / France Nouvelle (?)], the new [land]. And this country lies in the latitude of the world about 20 degrees [20 = כ'] from the equator [קו השוה], and in longitude 250 degrees [250 = ר"ן (?)]; and according to what is written, its [extent] and breadth is likewise reckoned as though it were a hundred by a hundred parsangs.

[74§] סימן ע"ד — The fifth part of the terrestrial globe — it too is in the New World — and that part is called Peru [פיר"ו = Peru]

Know that the New World which we mentioned, the researchers divided into two parts: the one [lying] to the north by itself, and the second to the south by itself. The northern part begins from its dividing boundary at the equator [מקו השוה] and onward toward the north, and the dwelling of [התורים (?)]...

שער ג (Gate 3) — continued

[continuation of] (74§) סימן ע"ד — Peru, the fifth part of the terrestrial globe

toward the northern pole, up to 64°30′. For most of the year those who venture there [?] cannot move any farther from the equator, even in summertime, because the dew that falls there grows cold and freezes, so that from the intense cold its appearance is like [?] silver, and like ice. [Several words here are hard to read: this part... to the side... there, or [?].] The second part inclines toward the south; this is its territory and its boundary. In terms of the latitude of the world, this part likewise begins at the tenth degree already mentioned, and extends southward beneath the equator and beyond it, toward the southern pole, about fifty degrees (a place [?] very close to the southern pole, as will be explained). In terms of the longitude of the world, this part begins on the western side at the 250th degree [ר"ן] and runs eastward to the 350th degree [ש"ן]. This second part is filled with land and provinces — a desirable land, good and broad, called Peru [פיר"ו], and it is after this province [of Peru? — of Sevilla?] [?] that the whole of this part is called Peru in general. [The two parts are] America [אמידק"ו [?] = America] and Peru, each on its own [?], [and each?] extends from the tenth degree from the equator toward the north, and the outermost [?]...

on the western side, from the 250th degree [ר"ן], and it extends toward the east [?]. [The text here describes the moderns dividing the New World into a northern part and this southern part.] The moderns added to the three parts of the world — that is, Africa [and Asia?] and Europe [וארופ"י] — and it was fitting for them to add [these New-World portions to the] books of the parts of the world.

(75§) סימן ע"ה — A brief note concerning the aforementioned Peru, which is the fifth part of the terrestrial globe, as above

The part [called] Peru, of which we spoke — most of its provinces lie beneath the belts of the zodiac, called in their tongue *zona torrida* [זו"ל טוריד"ד — Latin *zona torrida*, "the torrid zone"], that is, the "scorched belts." We already explained above, in §66, that the ancients judged that beneath the whole expanse of the belts — even for about twenty degrees to either side of them — no inhabitants could dwell, on account of the great heat and the great dryness of the land, for (they said) no grass or herb would grow there, nor any other plant, since all would be dry and parched from the great heat. But all this is contradicted [by the moderns?] [?]: [the men?] who now [survey/write of?] that land have seen [?] it gathered toward the edge — a land populous and full of every good thing. And there is reason to wonder greatly at this: how is it possible to endure and stand against so great and abundant a heat beneath the belt of the zodiac?

Therefore know that the Holy One, blessed be He, in His abundant kindness, reversed nature for the sake of these provinces beneath the belts of the zodiac, for the benefit of those who dwell there. For all those who dwell there beneath the belt — to the very degree that the sun draws near, directly over the point of their heads — to that same degree the winds and the rains of water grow strong for them, and the air of that land is by its nature cold and moist; and around the hours of midday, both before it and after it, the heavens most often grow dark with clouds, so that the clouds form a barrier between them and the sun, to shield them from the sun's burning heat. All this is among the wonders of Him who fashioned all. In any case, know that the heat and the [warmth?] [?] that remains there, even on a cloudy day, is very great and powerful — [enough to tax] the endurance of our own frailty, as [reported by?] discerning men who travel there [?], [where] year by year, roughly one in twenty-six [כ"ו] [?] — so it is reported there — most of them fall sick and wrap themselves up [?] from the great heat, and many of them die there.

Know, too, that in the provinces of Peru there are found many rivers and springs of cold water, just as in our own provinces, and grass and herbs and fruits and every kind of produce — they thrive more than in these lands [of ours]. The inhabitants of that land are not black, like the Kushites and the inhabitants of Africa [אפרי"קא], who are equally deep [?] toward the south and likewise dwell beneath the belt of the zodiac or near it; for the inhabitants of the part called Peru are not so darkened [?], as are the inhabitants of Africa. Within this part called Peru there is [?] a province called Basilias [ביסליא"ס — Brazil? [?]], [whose

land is a scarcity of hands? / a land that draws in hands? [?]] at the tenth degree of latitude, extending [?] toward the southern pole; and in [terms of] the longitude of the world [it lies at] about the 340th degree [ש"מ]. The land is blessed and built up, full of every good thing; and there is great wealth of silver and gold there — especially gold [?], reddish-blue [?] in [its ores? [?]]. There no rain falls; it is like the land of Egypt, and they have no fixed season for sowing, but they sow and reap there all the days of the year.

(76§) סימן ע"ו — Some say that the provinces of Peru are Ophir, whither King Solomon, peace be upon him, sent his ships

Know that the scholars who investigate the earth wrote that the land of Ophir [אופיר], whither King Solomon, peace be upon him, sent his ships to bring [gold?] [?] — to bring from there gold, as in Kings I ch. 9 ['סי' ט] and ch. 10 ['סי' י] and in Chronicles [chapters [?]] — that this is the kingdom of the aforementioned Peru; and they call it S'firo and Ophiro [ספיר"ו וחופ"ירו — "Ophir"] [?]. [The researchers — Kepler? / Copernicus? [?] — say so], and their words seem very plausible. For undoubtedly there was a great distance that [Solomon's ships] needed to travel and return over a span of three years, as Scripture says. This span of time our own contemporaries in our lands would need in order to go and return from it; and there [in that land] much gold is found, [more than in?] [?] all others. For the reasons mentioned, it is plausible to believe that S'firo [ספיר"ו] is Ophir. And accordingly [?] this New World, of which we have spoken, was [not?] [?] [unknown] before — rather our sages [knew of it], for it was already known in the days of Solomon, peace be upon him... [and it was rediscovered] in the year [5]232 [?] [רל"ב — perhaps 5252 = 1492 CE, the year of Columbus; the letters as printed give 5232 = 1472 CE [?]] of the sixth millennium, [on the voyage?] to explore the sea, and it was revealed [anew]. Thus this part, Peru, [was discovered] a second time, and their words are true according to reason.

But my heart [inclines otherwise]: since the ships that [Solomon] built at Etzion-Gever [returned], as it is written in Kings and in Chronicles as above, it appears that the ships went from Etzion-Gever upon the Red Sea [ים סוף] southward until they reached the Southern Ocean [ים אוקינוס הדרומי], and from there [turned?] [?] westward until they came to the land of Peru. And according to the author of *Me'or Enayim*, in ch. 8 [?] of his book, his ships passed along the whole length of the Great Sea [the Mediterranean] up to the edge of the land of Spain [ספר"ד], and from there through the Western Ocean [ים אוקינוס המערבי], thus [reaching it]. But his words cannot be right, for — as is well known regarding the boundaries of the

seas — he would [have to] concede and admit that the ships could not have come from Etzion-Gever upon the Red Sea [by such a route].

(77§) סימן ע"ז — Explanation of the sixth part of the terrestrial globe, called Guinea [גביניא"ה — Guinea [?]]

Know that twenty-[six? [?]] years after the discovery of the New World, [in the year?] [the fifth [?] millennium... 5]... — which for the Christians is the year [רע"ט 1279 = [?] of their reckoning? [?]] — the king of Portugal [פורטוגא"ל] sent [his emissary?] [and] Rodrigo [?] [ורדיגנג"ו [?]] Magellan [מנגליהנו"ם — Magellan [?]] to explore... ...to learn whether there is yet more inhabited land beyond this [New] World; for it [the New World] also extends there, tending toward the southwest. And in part [thirteen? [?]] [there is] another [region], as far as [?] the strait [מיצר [?]] of the sea that serves as a divider between the part of the New World called Peru and the southern part of the world (whose [nature] will be explained to you further on, and as you will see depicted in the map of the world). There the measure of length is about 100 [ק'] parsangs long, and its width is only 48 [מ"ח], and its distance from the equator toward the southern pole is 51 [נ"א [?]] degrees. (This sea — [that is, the strait] — they named after him, the Sea of Magellan [ים מגנליהמו"ם — the Strait of Magellan], and he passed through the strait in great peril because of the waves and the storms, and they entered into it; and it brought all of Peru to his right hand and their southern boundary to his left, and he kept sailing many days until he reached land — a great and broad expanse, apart from the islands of new Guinea [גיביניאיה — Guinea/New Guinea [?]] — and they made war [?] with the inhabitants of that land; and although Magellan [מחנגליהנו"ם] made peace [?]... [and was slain?] [?] in that war, nevertheless the scholars of Spain [ספרדי"ס] and the scholars of Portugal [פורט"ג] strengthened the [expedition's] force until the inhabitants of that land [were doubly subdued?] [?]...)

(78§) סימן ע"ח — The seventh part of the terrestrial globe, which is the northern world

We already explained that the ancients judged that from the northern circle onward, up to its pole, no inhabitants dwell, on account of the great cold and [?]... [A large part of it] is filled with the waters of the seas; and also part of its surroundings, where there is a [newly-found?] [?] expanse, is [a marvel]. And the reason for this [is] the great distance of the sun [from there]... [therefore they said] they cannot stand there because of the cold and the great [?]. And I have already mentioned this too, amid the many [investigations of the] researchers

[?]... that it is impossible [?] toward the northern side, as much as is possible [?]... [with variations] of degrees, [both] below and above, and so on [?]... [several words here are illegible]. ...beyond [that], as we said above. Moreover, since the surface of this part is great in its extent — for in its circumference it is more than 106 [ק"ו [?]] degrees, which amount, in square measure, to hundreds of parsangs of length — [the moderns filled it in?] with known provinces [added] to their number, [drawn] from the northern circle (if there are indeed inhabitants). And the researchers said that, because of its great size, it was fitting to make this great expanse a part in its own right [?] (§[63? [?]]).

[The area computation of the northern cap:] The surface of the northern [region] occupies [?] hundreds of parsangs by hundreds of parsangs [?]... Every degree of the northern circle, its distance from the axis is 23 [כ"ג [?]] degrees, 21 [כ"א] minutes [?]... the full measure of the diameter that each northern circle [subtends] contains [twice?] 53 [ו"ג [?]] degrees, 28 [כ"ח] minutes, which are about 47 [מ"ז] by 46 [מ"ו] degrees; and the circle around them, by their reckoning, [is] three times 46, which comes to 141 [קמ"א → margin: **141**]. And the area of this circle is known to us from the product of half its diameter with half its circumference, as was explained [in §29 [?]]. For half its diameter is 23½ [כ"ג ומחצה] and half its circumference is 70 [ע' [?]]... and the half [?] comes out to **1668** [Arabic numeral in the source]... [we take] the square root of [that?] product, and it comes to 4-hundred by 4 [?]... and every degree contains 15 [ט"ו] parsangs, so as to total [several] hundreds by [several] hundreds of parsangs; and this computation is simple for those who know the science of surveying. (Thus far the reasoning.)

(79§) סימן ע"ט — The eighth part of the terrestrial globe, which is the southern world, the largest of all the other parts of the world

This part is, in size, larger than any single one of the [other] parts of the world; and its surface contains almost the surface of all three parts of the world [together] — that is, Africa and Europe [and Asia]. And it is possible [?] to come to this part by way of the dry land [from each?] of the [other] parts of the world... just as one may come by way of the dry land from each of the three parts of the world, for its expansion [?] — even from S'firo [ספיר"ו] [?] to America [אמידיק"א]. For this southern part has already been explored [?], and Magellan [מרגנליהם [?]] — [at the end?] his instruments [?] — encircled the whole coastline of the southern world from all four directions of the world.

From [one] edge to the [other] edge, know that the whole southern circle, from edge to edge, begins from this part... at degrees 150 [ק"ן] and 140 [ק"ם [?]], along

the length of the inhabited region; this part reaches nearly to all [?] the degrees up to the equator, and it approaches the great island [?] near it by about 100 [ק'] parsangs. And along [longitude] 150 [ק"ן] [to?] 200 [ר' [?]], this part likewise reaches to the Tropic of Capricorn [עגול גדי] and beyond it, until [it comes] near the great island [called] [?] Guinea [כוכ"א גיביניאס [?]], and so forth.

Behold, we have here set down for you, in general, [an account of] the [eight? seven? [?]] parts of the world; and the researchers wrote [and we have transcribed] what [they said]... [namely] that many great and very large voyages [were undertaken], and many kings sent [ships] to explore the sea; and they crossed and encircled all [eight [?]] parts of the world [סל"ל [?]], and surveyed the whole coastline of the Ocean [אוקינוס] from edge to edge, and did not [leave]... ... [so that] not even one truth [?] remained that they did not encompass (part by part). They already [reached?] the equator toward the northern side [?] — but that they did not encompass, because they cannot press farther in that direction, on account of the great cold, as above in §74. They also crossed and surveyed the seas back and forth. (And in every place where water was disclosed to them — as well as [lands] near the shore of the sea or far from it — they recorded them all in a book: thus its location, in both longitude and latitude of the globe.) Henceforth, then, it is impossible and unfeasible that one more part be found beyond the eight [שמנה] parts of the world already mentioned; though within the southern part of the world it is possible that there dwell peoples [?] and special [nations?] and countless provinces — for this land [?] has not [yet] been known or investigated as one through which any man has passed.

(80§) סימן פ' — Who told the geographers the locations of the world and the boundary of the seas?

And if you should ask and say: who is it that revealed this secret to us — [the disposition of] all the places of the world, both sea and dry land, and likewise the boundaries of the seas, their length and their breadth — and at what time was this achievement accomplished? Know that this matter was not made known to us by any one man, nor at any one time. For many great and wise, discerning sages, in earlier generations — this [being] before [our time by] some thousands of years [?] — all the men who labored in their wisdom over the science of the stars, the ancients too strove to know the boundaries of the earth: such as Archimedes [ארקמי"ד — Archimedes [?]], and [Hipparchus? Abraham? [?]] [אברכו"ם], and Ptolemy [בטולמיי"ם], as is found written [at length?] in their books. And after them, the scholars added to inquire into this in every generation, until in our own time researchers such as those before us investigated and inquired

into the boundaries of the dry land, together with the boundaries of the seas — great scholars, who labored over this all the days of their lives.

The chief investigations, great and wondrous, concerning the boundaries of the seas and the dry land [came] from the time the New World was discovered. [They were undertaken] by [?] great and mighty kings, as detailed — [at one time and another?] — and also the kings of [?] [נרע"ת [?]] Spain [ספר"ד] and Portugal [פורגנג"ל], who strove to know the settlements and the boundaries of the whole terrestrial globe, [and] brought it [to light] with markers [?], by means of [?] wise and discerning men who knew well the science of Geography [גיאוגרפי"א — Greek γεωγραφία], which is the science of measuring the earth combined with the science of the stars and the constellations. They provided them [with] provision — food and stipend and much reward and payment — and sent them, together with officers and many attendants, to all the directions of the inhabited world; and likewise they prepared for them many ships and sent in them, in the same way, wise men and men learned in science, to explore the sea, to encompass its whole shore from every corner, and to traverse it in its length and breadth — many kings [sending them] back and forth — to investigate all the islands, near and far.

And in every place they came, whether by sea or by dry land, they carried out the observations by means of the science of the stars, with the measuring instrument [כלי] in their hands, [determining] the longitude and latitude of that place, and they recorded it in a book. The sages have already set forth their words on this, and they wrote many further books — great and expansive matters — not only [concerning] the many locations of the whole globe of the world, but also the natural order and the configuration of every province under the heavens. And there is no room to elaborate here.

(81§) סימן פ"א — How and from where did the researchers come to know the latitude of provinces (between north and south) and their longitude (between east and west)?

Determining the measure of the latitude of provinces in every place of the world — whether at sea or on dry land — how far its distance [from the equator], how many [degrees] from the equator [קו] [it lies] [?] — this is a very easy matter, for even schoolchildren, in a short while, will grasp it... without any labor, [in contrast to] what [the ancients?] toiled and wearied over. And its usefulness has [in part] already been explained to you above, at the end of Gate 2, in §51 [סי' נ"א]. It will be explained to you still more fully [?] in the Gate of [the calendar /

the year?] [?] — that is, [Gate 11? / §... [?]] — where the determination of [one's position?] directly against the axis will be explained to you, by [several] methods, [namely] how far it [lies] from the equator, as above in §48 [סי' מ"ח].

Now as for knowing the longitudes of provinces, by the method by which the measure of the longitude of every settlement became known to them — as was explained above in §61 [סי' ס"א] — and likewise the author of [*Yesod Olam*?] [ישראלי — [R. Isaac] Israeli, in his book *Yesod Olam*], wrote about this, in *ma'amar* 87 [מאמר פ"ז]: that the ancient sages, who sought to know how many degrees of altitude [a given] city [stands at?] [?], or how many degrees or miles [one] city [lies] from another city — they would station two observers, near and far, [as] discerning [men of] science [?], in [each of] the two places whose longitudinal distance apart they sought to know. And each of the observers fixed, with great precision, upon the very first moment when the moon entered into a certain known eclipse [לקות] — how many equinoctial hours and moments it was before or after midnight. And when all this was set down in writing, in detail, from each [observer], it was easy for the researchers to know the [difference?]... [and] this [difference], by that very [interval], is [proportional to] the distance of the cities one from another. That is: [if] one [degree? one hour?] appears in eclipse [?] to Reuben one hour before it appears to Shimon, it is known that the distance between them is 15 [ט"ו] degrees — for the [luminaries? [?]] dwell [travel] thus [around?] the globe of the world each day, that is, in 24 [כ"ד] hours, [each hour] the same [amount]. And it is already known that the degrees of the circle are 360 [ש"ס]; and when you divide this number by 24, [being] the hours of the day, there falls to each hour a revolution of 15 [ט"ו] degrees. So a difference of 2 hours will be [equivalent to] a distance of 30 degrees, and so on always, by this reckoning: every distance of 15 degrees causes a difference of 1 hour; up to 12 hours, when the difference between them is at its extreme — a distance of 100 [ק' — recte 180? [?]], which is 180 [ק"פ] degrees.

(§82) סימן פ"ב — To find the longitudes of provinces without eclipse observations

Know that the ancient sages learned the longitudes of provinces by means of two men who observed, with great precision, the moment [the moon reached] a certain [point] in its eclipse; [likewise] it was in their power to mark the moment [the moon reached] a certain line, or a portion of it. And [what] appeared [as] the same moment [?] to Reuben, one hour before Shimon, [means] — as is known — the distance between them is 15 [ט"ו] degrees. [This is] like the rule of those who observe the time of an eclipse of the moon. By this second method you can find

the longitudes of every province, whether at sea or on dry land, all the days of [your life?], and you need not wait and watch for the time of an eclipse.

And it is evident that the two aforementioned tests [?] — that is, [observing] the moon at the time of its eclipse, and [observing] the moon over against a certain [reference point] — both require that, when the two provinces or cities in which the observers [are stationed], both of them are seated upon the equator, or [both] are seated upon [the same] line or [the same] parallel [?]... [and] the difference [?] from west to east [?]... — [in that case] the distance [?] between them, in this manner and by this reckoning, [is as above]. But when the two of them are not upon [the same] line or [the same] parallel, or...

(83§) סימן פ"ג — To find the longitudes of sea islands, without eclipse observations and without two observers

In knowing the longitudes of the islands of the seas — or when the ship stands out at sea, far from the dry land [by many hundreds of parsangs?], in places where no observer-emissaries ever stood — [determining longitude] not at the time of a lunar eclipse and not at the time [the moon] is over against a certain [meridian], is a very difficult matter: how are we to know how many degrees [it stands from the edge?] of the world, from the [eastern?] edge to the west? Know that this matter can be known to us by means of newly-invented instruments. For this, you must first observe the time and moment [the moon reaches] the beginning of a certain sign, over against a certain [reference], by which [determination] you will be able to reckon out for yourself all the degrees [?]; and [thereby you find], [even without] two observers, the longitudes of provinces — and even the longitudes of the islands of the sea, or [the longitude] where the ship stands out in the midst of the sea, far [from any land]. This [depends] upon your knowledge of the [course] of the moon at a certain place, [set out] in the [Rudolphine?] [?] [tables] — in how many degrees [the moon] stands, [reckoned] against the signs of the zodiac, on every day of all the days of the year, at its rising and its setting, [and its position?] relative to the noon-line of that place — [as given] in the tables called in their tongue, after their days [?], [the Rudolphine Tables? — ימי רודיר"ם [?]]. And these [tables were computed?] for every city and city, [for] the lands they [the astronomers] wrote of, [and made known] to the sages; and I say, for example, that once the aforementioned tables have been fitted to the horizon of a certain city — behold, when [the ship is] far out on the [high?] sea [?], and we seek there to know the measure of the longitude of that place, we observe on that night the revolution of the moon, as it rises and its center reaches... ...to the beginning of a certain sign. And I say, for example, that

we observe upon it, at the beginning of the eve of the 15th of the month of Cheshvan, and we find its center to be against the head of the sign Taurus [ראש מזל שור]; and if the moon stood over a certain line [some hours?] earlier — this we determine by [computing] the aforementioned tables that were gathered [computed] for the [given] horizon and city. For example, [suppose] we found that on the third day [?], when the moon's center reached the beginning of the sign Taurus, the moon had already descended from the noon-line by 1½ hours [שעה ומחצה]. We know from this that the difference in the day-arc between the two places is 1½ hours — the moon's center [passing] over the noon-line earlier in the west [?]. And it is found, accordingly, that a certain city inclines toward the eastern quarter [?] — by half [?], according to the [daily] motion of the sun [?], [which travels] in the time of 1½ hours some 22½ [כ"ב ומחצה] degrees, by the reckoning of 15 degrees per hour — inasmuch as [the meridian] of the certain [reference] line, over which the aforementioned tables were gathered, we already know to be distant from the western edge by 32 [ל"ב] degrees and 12 [י"ב] minutes [?], so that the distance of the second place from the western edge to [dry land?] is only 7½ [ז' ומחצה] degrees. (And all this [holds] when the certain place and the second place [both lie] upon the line [that runs] from west to east, as above.) So then, this certain city is found [to lie] 20 [כ'] degrees latitude from the equator, and the latitude of the second [place] from the equator [is...] [?].

(84§) סימן פ"ד — To know the longitudes of provinces by the time of the moon's revolution, according to its own [proper] motion and the desired [motion], combined with the revolution of the daily sphere

Yet another way to find the places of the world by means of the motions of the world and [the daily] sphere, according to the time of the moon's revolution — [reckoned] by its proper motion and its desired motion — and according to the time of [its] revolution with the daily sphere. And I say, for example, to one who has understood [?]: [suppose] we are in a certain place among the places of the world whose longitude, from the western edge, we seek to know. We observe there the revolution of the moon; and [suppose that] on the eve of the ninth of the month of Kislev, for example, [we find] that it has descended in its proper motion — which is from west to east — to the beginning of the eighth degree of the sign Leo [מזל אריה]; and thereafter [?] we reckon thus [?] [by] the tables that were fitted to the horizon of [the Prolegomena? — פרלגומננון [?]], according to the reckoning that on the aforementioned night, at [that] degree, the moon will enter the tenth degree of the sign Leo. (And it makes no [practical] difference whether the two aforementioned entries be from here or from there, and [whether] the eastern [point lies] to the noon-line thus, [or] somewhat to the west of the noon-

line itself; for in every case [the method holds] for you — [namely] that at the moment and time of midnight, when the moon comes to the midnight-line, which, according to the two aforementioned entries, [its proper course?] shows it to have descended in its proper [motion], [it] precedes midnight in a certain [place] by [?] two [degrees] at the [given] place opposite.) And according to what we already know — that the moon's revolution, in its proper motion in its sphere, is about 22 [כ"ב] degrees in [24 hours? [?]], as will be explained further on in §157 [סי' קנ"ז [?]] — [it follows] that the moon's proper revolution over the two aforementioned degrees [takes] four [ד'] hours. And we know from this that midnight in a certain [place] precedes midnight in the [reference] place, the difference between them being four [ד'] hours, which, from the time...

שער ג (Gate 3)

(85§) סימן פ"ה — The boundaries of the four directions of the world: where they begin and where they end

[The opening of §85 continues from the foot of the preceding page, completing the discussion of §84 on finding a place's longitude from the motion of the moon; the daily circuit is described as nearly uniform, "close" at every hour.]

The author says: Since we have profited from the tables that give the longitude and latitude of the various regions, I saw fit in this Gate to treat the directions of the world and their great revolution — a matter of much benefit to those learned in the science, and in particular to seafarers, for plotting their course, and to the teacher of astronomy, for orienting himself and aiming toward a given place.

The world as a whole is divided, in accordance with what our Sages [?] have laid down. The lines that run [north–south] are called "latitude" (רוחב), and those that run [east–west] are called "longitude" (אורך); and the celestial sphere was fitted out with its four quarters accordingly. The ancients likewise reckoned only from these four quarters of longitude, [measuring] from every nation and tongue. [Cf. Tehillim 19:5, "their line has gone out through all the earth."] [?]

Each of the four quarters has its boundary where it begins and where it ends, measured from the western edge [the meridian of the Fortunate Isles]. [The eastern quarter runs] up to the sign of Cancer [מזל סרטן], and [the southern] to the sign of Capricorn [מזל גדי]. [The specific boundary values given here — on the order of 23°, 46°, and figures in the hundreds of parasangs — could not be read with confidence from the source: numeral: ?] The longitude of the north [runs] to

a total of some [numeral: ?] parasangs, and likewise the longitude of the west; so that these are the two [complementary] measures. [?]

[Several clauses of this dense passage, giving exact degree- and parasang-figures for where each quarter begins and ends, are too abraded/small to recover at the available resolution numeral: ?]

(§86) סימן פ"ו — That the ancients divided the [dividing-circle], that is the horizon, into twelve winds

Know that the ancient investigators divided the curvature — the [dividing-circle], that is the horizon — into twelve parts, splitting each of the four winds of the world into three equal parts. For example, the east wind they divided into three: the northern part they called [east], the part to its right they called southeast (מזרחית דרומית), and the [remaining] part they called northeast (מזרחית צפונית); and so, by the same rule, for the rest of the winds.

You should know, accordingly, that there is [a difference / no difference] [?] between "the east corner" (קרן מזרחית) and "the northeast," and so forth — for the word "corner" (קרן) carries a distinct sense: a city situated at point [א] lies in the [east] portion, while a city at point [ב] lies in the northeastern portion, the difference in longitude between them being [numeral: ?] degrees. And all of this is in accordance with the words of the Torah, as [set out] in this figure. [?]

(§87) סימן פ"ז — That the moderns divided the terrestrial circle, that is the horizon, into thirty-two winds

Know that the scholars among the moderns — the geographers (מחקרי הארץ) — agreed to divide the horizon, this circle, [into finer parts] because of the great benefit [to navigation]. To sailors and [travelers] and directions in general they gave names. Upon the four winds of the world they added four more winds and called them: northeast (מזרחית צפונית) [reading uncertain], southeast (מזרחית דרומית), northwest (צפונית מערבית), and southwest (מערבית דרומית) — [naming each] neither purely "east" nor purely "west," and so on, since the essence of them is east and west. These [eight] they called the "principals," or "mothers" (/ אבות ראשונים), for a reason to be explained.

The moderns then saw fit to add to the eight winds just named still more, dividing the dividing-circle into thirty-two winds — assigning to each [principal] wind [additional subdivisions]. These further-added winds they called by compound names, and these are their names, as they named them: (א) east-northeast; (ב) east-southeast [and] east[-…]; (ג) west[-…]; (ד) and likewise the fourth, west-

southwest; and so for the added winds toward [the poles]: (ה) north-northeast [and] north-northwest; and likewise toward the south (ו) south-southeast; … (ח) south-southwest. [The enumerated compound-wind names (א)–(ח) are partly abraded; several individual readings are uncertain: numeral/label: ?]

It emerges that each wind spans eleven and one-quarter degrees — that is, 11°15′ — since a thirty-second part [ל"ב] of the surrounding circle of 360° is 11¼°. [From mid-east, a span of some 33°[?] …] [?]

[The moderns also employ the magnetic needle: an instrument that shows the hours "by the tongue of the needle" (מחט מגנעטיכא [magnetic]) together with the lodestone (אבן השואב) that draws iron (ברזל) to it, indicating the [meridian] line and the noon-line at every moment. [?]]

Diagram. A wind-rose (compass rose) enclosed in a circular double rim, with a many-pointed (eight-armed, hatched) compass star at its center. A pennant on a knotted staff stands to the left of the rose; the staff-foot is marked with the letter **ב** [bet]. Around the rim the directions are lettered; the legible ones are:

- רוח צפונית ("north wind"), at the top, with **צפון** ("north") at the center-top
- רוח דרומית ("south wind"), at the bottom, with **דרום** ("south")
- מזרח ("east") on the right-hand side
- מערב ("west") on the left-hand side
- מזרחית צפונית ("northeast") [?] — upper right arc
- מזרח דרום ("southeast") [?] — lower right arc
- [additional intercardinal labels on the left/lower-left arc are present but too worn to read with confidence: label ?]

[More than two rim-labels are uncertain; the figure]

(§88) סימן פ"ח — An alphabetical table, from which to know the location of many inhabited places, and also of some sea-islands: how much each of them is in the world's longitude and in its latitude

I saw fit, in concluding this Gate, to append the table of "[The Table of] the LORD" [?], arranged in alphabetical order, in which you will find many inhabited places, and also some of the islands of the sea — how much each of them stands in the world's longitude and in its latitude. Some [longitudes] are measured from the east; [the reference used here is Jerusalem, whose longitude is …] [numeral: ?]. Know that the longitude is reckoned from the west [the meridian of the Fortunate

Isles], and the latitude from the equator [?]. And now, enter and study, [and] know from this table the locations of the places of the world.

The alphabetical gazetteer (§88). In the source, each entry runs right-to-left: **place-name**, then **latitude** (מעלות degrees, דקים minutes), then **longitude** (מעלות degrees, דקים minutes). The columns below preserve that logical order. Latitude degrees were the most legible cells and are given where read with confidence; **minute-values and the entire longitude column are low-confidence at the available resolution and are largely flagged `[numeral: ?]` — the numeric interior of this table** Place-names (the argument column) are given in full with identifications where possible.

אות א (Letter Aleph)

Place (source)	Identification	Latitude	Longitude
אלכסנדריאה	Alexandria	31°10′	[numeral: ?] (≈60°?)
אלקוירא	al-Qāhira (Cairo)	29°50′	[numeral: ?]
אנטיוכא	Antioch	38°35′	[numeral: ?]
אנט ווארף	Antwerp	[numeral: ?]	[numeral: ?]
אקווילי	Aquileia [?]	43°30′ [?]	[numeral: ?]
אויקשפרג	Augsburg	47°42′	[numeral: ?] (32°18′?)
אורלינגעניץ	[Erlangen? / Nördlingen? ?]	47°13′ [?]	[numeral: ?]
אולמא	Ulm	48°[?]′	[numeral: ?]
אויטינגע	[Öttingen? ?]	48°58′ [?]	[numeral: ?]
אינגלשטט	Ingolstadt	48°6′ [?]	[numeral: ?]
אויבען	[Eupen? ?]	47°10′ [?]	[numeral: ?]
אויך	[Aachen? ?]	[numeral: ?]	[numeral: ?]
אולמיין / אולמיץ	Olmütz (Olomouc) [?]	[numeral: ?]	[numeral: ?]
אמשטרדם	Amsterdam	52°40′ [?]	[numeral: ?]
אנדרינופל	Adrianople (Edirne)	[numeral: ?]	[numeral: ?]
אוזן בריק	Osnabrück	[numeral:	[numeral: ?]

Place (source)	Identification	Latitude	Longitude
		?]	
אוסטרא	[Ostrog? / Austria? ?]	[numeral: ?]	[numeral: ?]
אלוני ממרא	Elonei Mamre (the Oaks of Mamre, by Hebron)	[numeral: ?]	[numeral: ?]
אים לנד	[Eyland / "island"? ?]	[numeral: ?]	[numeral: ?]
אנדריך / אנדרך	[?]	[numeral: ?]	[numeral: ?]
אשקלון	Ashkelon	[numeral: ?]	[numeral: ?]

אות ב (Letter Bet)

#	Place (source)	Identification	Latitude	Longitude
1	אבל / באל	[Basel? ?]	[numeral: ?]	[numeral: ?]
2	בגדור	[Baghdad? ?]	34°[?]′	[numeral: ?] (88°6′? — high, flagged)
3	ביצלוני	Barcelona	41°35′	[numeral: ?]
4	בומבערגם	Bamberg	49°56′ [?]	[numeral: ?]
5	באזיל	Basel	47°41′ [?]	[numeral: ?]
6	בערלין	Berlin	52°50′ [?]	[numeral: ?]
7	באנוניא	Bologna (Bononia)	[numeral: ?]	[numeral: ?]
8	ברוקו לנדין	[London? / "Bruck–London" ?]	51°24′ [?]	[numeral: ?]
9	ברעסלא	Breslau (Wrocław)	51°10′ [?]	[numeral: ?]
10	ברונשווייג	Braunschweig (Brunswick)	[numeral: ?]	[numeral: ?]
11	ברעמין	Bremen	[numeral: ?]	[numeral: ?]
12	ברסק דליטא	Brisk d'Lita (Brest-Litovsk)	51°10′ [?]	[numeral: ?]

#	Place (source)	Identification	Latitude	Longitude
13	בעלז	Belz	[numeral: ?]	[numeral: ?]
14	בית לחם	Bethlehem	31°3′ [?]	[numeral: ?] (65°48′?)
15	באר שבע	Beer Sheva	[numeral: ?]	[numeral: ?]
16	בוזק	[Bozk? ?]	[numeral: ?]	[numeral: ?]

אות ג (Letter Gimel)

#	Place (source)	Identification	Latitude	Longitude
1	נענובא / גענובא	Genova (Genoa)	43°50′ [?]	[numeral: ?]
2	געלרריא	[Gera? / Calabria? ?]	52°[?]′	[numeral: ?]
3	גראנטי / גראנטש	[Granada? / Grantham? ?]	37°50′ [?]	[numeral: ?]
4	גערליזן	Görlitz	51°10′ [?]	[numeral: ?]
5	גניוין	[Gniezno? ?]	[numeral: ?]	[numeral: ?]
6	גרמיירא	[?]	[numeral: ?]	[numeral: ?]
7	גרעץ ששיר	[Graz? ?]	[numeral: ?]	[numeral: ?]
8	גראן אונגריא	Gran (Esztergom), Hungary	[numeral: ?]	[numeral: ?]
9	גרונדא / גרונרא	[Grodno? ?]	[numeral: ?]	[numeral: ?]
10	גבעין	Gibeon (גבעון)	[numeral: ?]	[numeral: ?]
11	גת	Gath	[numeral: ?]	[numeral: ?]
1	גראן לנד	Greenland ("Gran	[numeral: ?] (—"עין"/	[numeral

#	Place (source)	Identification	Latitude	Longitude
2		Land")	blank?)	: ?]

אות ד (Letter Dalet)

#	Place (source)	Identification	Latitude	Longitude
1	דמשק	Damascus	33°[?]′	[numeral: ?]
2	דאנציק	Danzig (Gdańsk)	54°[?]′ [?]	[numeral: ?]
3	דרעזין	Dresden	[numeral: ?]	[numeral: ?]
4	דערטמונר	Dortmund	[numeral: ?]	[numeral: ?]
5	דן היא לשם	Dan (which is Laish / Leshem)	[numeral: ?]	[numeral: ?]

אות ה (Letter He)

#	Place (source)	Identification	Latitude	Longitude
1	המבורג	Hamburg	53°[?]′ [?]	[numeral: ?]
2	הלברשטט	Halberstadt	[numeral: ?]	[numeral: ?]
3	הידל בורג	Heidelberg	[numeral: ?]	[numeral: ?]
4	הנובר	Hanover	[numeral: ?]	[numeral: ?]
5	הילרסים	Hildesheim	[numeral: ?]	[numeral: ?]
6	האלי דוקסין	Halle (in Saxony) [?]	[numeral: ?]	[numeral: ?]
7	הילני אינזל	St. Helena Island ("Helena Insel")	[numeral: ?]	[numeral: ?]
8	הר סיני	Mount Sinai	[numeral: ?]	[numeral: ?]
9	הר כרמל	Mount Carmel	[numeral: ?]	[numeral: ?

#	Place (source)	Identification	Latitude	Longitude
				]

אות ו (Letter Vav)

#	Place (source)	Identification	Latitude	Longitude
1	ווינציאה	Venice (Venezia)	45°[?]′	[numeral: ?]
2	ורוני בעצן / ודוני בעצן	[Verona? ?]	45°[?]′ [?]	[numeral: ?]
3	ויאונ' דצרפת	Lyon of France (Lyon)	45°12′ [?]	[numeral: ?]
4	וויטן בערג	Wittenberg	51°[?]′ [?]	[numeral: ?]
5	ווילנא דליטא	Vilna of Lithuania (Vilnius)	55°[?]′ [?]	[numeral: ?]
6	ווירין בורג	Würzburg	49°[?]′ [?]	[numeral: ?]
7	ווירמיש	Worms (Wormaisa)	[numeral: ?]	[numeral: ?]
8	וויצענץ	Vicenza	[numeral: ?]	[numeral: ?]
9	וורשא דמזא	Warsaw ("Warsha d'Mazovia")	[numeral: ?]	[numeral: ?]
10	ווינא	Vienna	[numeral: ?]	[numeral: ?]

אות ז (Letter Zayin)

The heading **אות ז** appears at the foot of the left-hand block; no entries fall within this page. The table continues onto the following page.

Section שער ג (Chapter 3). This batch completes the alphabetical gazetteer of §88 (letters ז through ש, pp. 65–67), then continues with §89, §90, and §91 (pp. 67–68), plus two wind-rose figures.

§88 (continued) — Gazetteer of places by the order of the alphabet

Table reads right-to-left in the source. Each entry: place-name | latitude (°,′) | longitude (°,′); the number-group adjacent to the name is latitude, the outer group longitude. Names garbled by the compositor are identified from context and flagged [?] where uncertain.

אות ז (Letter Zayin) — p. 65

Place	Latitude	Longitude
זלצבורג [Salzburg]	[numeral: ?]	[numeral: ?]
זמשט דפולין [Zamość, Poland]	[numeral: ?]	[numeral: ?]
זיגעט [Sighet? / Zieget] [?]	[numeral: ?]	[numeral: ?]
זונט [?]	[numeral: ?]	[numeral: ?]
מיגן [recte זיגן = Siegen?] [?]	[numeral: ?]	[numeral: ?]
זושט [Soest?] [?]	[numeral: ?]	[numeral: ?]
זיף [Ziph (biblical; Yehoshua 15:24)]	[numeral: ?]	[numeral: ?]

אות ח (Letter Chet) — p. 65

Place	Latitude	Longitude
חמת אנטוכיא [Hamath = Antioch ("Hamat of Antioch")]	[numeral: ?]	[numeral: ?]
חברון [Hebron]	[numeral: ?]	[numeral: ?]
חורב [Horeb (Mount)]	[numeral: ?]	[numeral: ?]

אות ט (Letter Tet) — p. 65

Place	Latitude	Longitude
טלטול ספרד [Toledo, Spain]	מא [41]	[numeral: ?]
טוני דמצרים [Tunis of Egypt? / "borders of Egypt"] [?]	[numeral: ?]	[numeral: ?]
טוני ברבריא' [Tunis of Barbary] [?]	[numeral: ?]	[numeral: ?]
טריר [Trier]	[numeral: ?]	[numeral: ?]
טארין [Turin] [?]	[numeral: ?]	[numeral: ?]
טבירי' [Tiberias]	[numeral: ?]	[numeral: ?]

אות י (Letter Yod) — p. 65

Place	Latitude	Longitude
ירושלים [Jerusalem]	לב [32]	[numeral: ?]
יענט [Ghent? / Jena?] [?]	[numeral: ?]	[numeral: ?]
יערסלאוו [Jarosław / Yaroslav]	[numeral: ?]	[numeral: ?]
יובא אי [island of Java? "Yuba island"] [?]	[numeral: ?]	[numeral: ?]
יריחו [Jericho]	[numeral: ?]	[numeral: ?]
יפו [Jaffa]	[numeral: ?]	[numeral: ?]
יבנה [Yavneh]	[numeral: ?]	[numeral: ?]

אות כ (Letter Kaf) — p. 65

Place	Latitude	Longitude
כרמל ראלי' [Mount Carmel of Elijah — כרמל דאליהו]	[numeral: ?]	[numeral: ?]
כרמל דנבות [Carmel of Naboth (the vineyard of Naboth; Melachim I 21)]	[numeral: ?]	[numeral: ?]

אות ל (Letter Lamed) — p. 65

Place	Latitude	Longitude
לונדן [London]	[numeral: ?]	[numeral: ?]
לויפק [?]	[numeral: ?]	[numeral: ?]
לימן הצרפת [Le Mans, France? / Limoges] [?]	[numeral: ?]	[numeral: ?]
לוינעבורק [Lüneburg]	[numeral: ?]	[numeral: ?]
לייפצוג [Leipzig]	[numeral: ?]	[numeral: ?]
לייזיבין [?]	[numeral: ?]	[numeral: ?]
לינץ [Linz]	[numeral: ?]	[numeral: ?]
לובלין [Lublin]	[numeral: ?]	[numeral: ?]
לעמבורג [Lemberg / Lviv]	[numeral: ?]	[numeral: ?]
לאדמער [Ladmir / Volodymyr (Lodomeria)]	[numeral: ?]	[numeral: ?]
לשם הוא דן [Leshem, which is Dan (biblical; Yehoshua 19:47)]	[numeral: ?]	[numeral: ?]

אות מ (Letter Mem) — p. 65

Place	Latitude	Longitude
מצרים [Egypt (Mitzrayim); printed מצדים]	[numeral: ?]	[numeral: ?]
מעניץ [Mainz] [?]	[numeral: ?]	[numeral: ?]
מעביל [?]	[numeral: ?]	[numeral: ?]
מיידבורק [Magdeburg]	[numeral: ?]	[numeral: ?]
מאנטובא [Mantua]	[numeral: ?]	[numeral: ?]
מרסלא צרפ' [Marseille, France] [?]	[numeral: ?]	[numeral: ?]
מיודיקיא [?]	[numeral: ?]	[numeral: ?]
מיילנד [Milan (Mailand)]	[numeral: ?]	[numeral: ?]
מרפוק [?]	[numeral: ?]	[numeral: ?]
מוינכן [Munich (München)]	[numeral: ?]	[numeral: ?]
מגין [?]	[numeral: ?]	[numeral: ?]
מוינשטר [Münster]	[numeral: ?]	[numeral: ?]
מינדין [Minden]	[numeral: ?]	[numeral: ?]
מאנגאל [?]	[numeral: ?]	[numeral: ?]

אות נ (Letter Nun) — pp. 65–66

Place	Latitude	Longitude
נרבונק דצרפ' [Narbonne, France] [?]	[numeral: ?]	[numeral: ?]
ניאפלוס [Naples]	[numeral: ?]	[numeral: ?]
נירן בורג [Nürnberg]	[numeral: ?]	[numeral: ?]
נומברג רוזל [Naumburg?] [?]	[numeral: ?]	[numeral: ?]
נבערן [?]	[numeral: ?]	[numeral: ?]
נייס [Neisse (Nysa)?] [?]	[numeral: ?]	[numeral: ?]
גורט הוליין [?]	[numeral: ?]	[numeral: ?]
נורטם [?]	[numeral: ?]	[numeral: ?]
נינוה [Nineveh]	[numeral: ?]	[numeral: ?]
נור וירן [?]	[numeral: ?]	[numeral: ?]

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אות ס (Letter Samekh) — p. 66

Place	Latitude	Longitude
סיבילאה [Seville (Sevilla)]	[numeral: ?]	[numeral: ?]
סירן גיאה [Syracuse? / Cyrene?] [?]	[numeral: ?]	[numeral: ?]
סלינעק [?]	[numeral: ?]	[numeral: ?]
סיני [Sinai (Mount)]	[numeral: ?]	[numeral: ?]
סדום [Sodom]	[numeral: ?]	[numeral: ?]

אות ע (Letter Ayin) — p. 66

Place	Latitude	Longitude
ערפורט [Erfurt]	[numeral: ?]	[numeral: ?]
עסלינגן [Esslingen] [?]	[numeral: ?]	[numeral: ?]
ערלא דאונגרין [Erlau of Hungary = Eger] [?]	[numeral: ?]	[numeral: ?]
עמרן [?]	[numeral: ?]	[numeral: ?]
עצין גבר [Etzion-Geber]	[numeral: ?]	[numeral: ?]

אות פ (Letter Pe) — p. 66

Place	Latitude	Longitude
פראג [Prague]	[numeral: ?]	[numeral: ?]
פ"פ דמיין [Frankfurt am Main]	[numeral: ?]	[numeral: ?]
פ"פ דאדרה [Frankfurt an der Oder]	[numeral: ?]	[numeral: ?]
פירדא [Ferrara? / Fürth?] [?]	[numeral: ?]	[numeral: ?]
פאנצישטי [?]	[numeral: ?]	[numeral: ?]
פנום ראפרן [?]	[numeral: ?]	[numeral: ?]
פרייבורק [Freiburg]	[numeral: ?]	[numeral: ?]
מייסן [Meissen]	[numeral: ?]	[numeral: ?]
פרייבורג [Freiberg]	[numeral: ?]	[numeral: ?]
פרישן [?]	[numeral: ?]	[numeral: ?]
פולרענץ [Florence (פלורענץ)?] [?]	[numeral: ?]	[numeral: ?]
פאביאה [Pavia]	[numeral: ?]	[numeral: ?]
פארמה [Parma]	[numeral: ?]	[numeral: ?]
פאריבה [?]	[numeral: ?]	[numeral: ?]

Place	Latitude	Longitude
פאריש [Paris]	[numeral: ?]	[numeral: ?]
פאסא [Passau? / Padua?] [?]	[numeral: ?]	[numeral: ?]
פוגוא [?]	[numeral: ?]	[numeral: ?]
פישרקוב [Piotrków]	[numeral: ?]	[numeral: ?]

אות צ (Letter Tzadi) — p. 66

Place	Latitude	Longitude
צוען מצרים [Zoan of Egypt (Tanis)]	[numeral: ?]	[numeral: ?]
צוריך שווייץ [Zurich, Switzerland]	[numeral: ?]	[numeral: ?]
צוויקא מייסן [Zwickau, Meissen] [?]	[numeral: ?]	[numeral: ?]
צעמלאנובא [?]	[numeral: ?]	[numeral: ?]
צור [Tyre (Tzor)]	[numeral: ?]	[numeral: ?]
צדון [Sidon (Tzidon)]	[numeral: ?]	[numeral: ?]
צפת [Safed (Tzfat)]	[numeral: ?]	[numeral: ?]
ציין [Zion? / Zeitz?] [?]	[numeral: ?]	[numeral: ?]

אות ק (Letter Kuf) — pp. 66–67

Place	Latitude	Longitude
קראקובא [Kraków]	[numeral: ?]	[numeral: ?]
קרימונא [Cremona]	[numeral: ?]	[numeral: ?]
קליקוט [Calicut]	[numeral: ?]	[numeral: ?]
קאנניאה [Cana? / Kanya?] [?]	[numeral: ?]	[numeral: ?]
קרטגינא [Cartagena / Carthage] [?]	[numeral: ?]	[numeral: ?]
קאשור דאונגרין [Kaschau of Hungary = Košice] [?]	[numeral: ?]	[numeral: ?]
קייריא [Cairo]	[numeral: ?]	[numeral: ?]
קלונ ד'רינוס [Cologne on the Rhine (Köln)]	[numeral: ?]	[numeral: ?]
קונם טנשינא [Constantinople? / Constantina] [?]	[numeral: ?]	[numeral: ?]
קרטובא [Córdoba (Cordova)] [?]	[numeral: ?]	[numeral: ?]
קורשיקעי [Corsica] [?]	[numeral: ?]	[numeral: ?]

Place	Latitude	Longitude
קאשטשן [?]	[numeral: ?]	[numeral: ?]
קאבלוצן [?]	[numeral: ?]	[numeral: ?]
קאפין האגין [Copenhagen]	[numeral: ?]	[numeral: ?]
קמניץ פדולי [Kamianets-Podilskyi]	[numeral: ?]	[numeral: ?]
קיניגסבערג [Königsberg]	[numeral: ?]	[numeral: ?]
קופו אינס [?]	[numeral: ?]	[numeral: ?]
קריכן ד'וישבתיג [?]	[numeral: ?]	[numeral: ?]
קרשברנע [?]	[numeral: ?]	[numeral: ?]
קיובא [Kiev (Kiova)]	[numeral: ?]	[numeral: ?]
קאבלא [?]	[numeral: ?]	[numeral: ?]
קראקא [Kraków?] [?]	[numeral: ?]	[numeral: ?]

אות ר (Letter Resh) — p. 67

Place	Latitude	Longitude
רומי [Rome]	[numeral: ?]	[numeral: ?]
רבינא אטלי' [Ravenna, Italy]	[numeral: ?]	[numeral: ?]
ראסניק [?]	[numeral: ?]	[numeral: ?]
רעביל [?]	[numeral: ?]	[numeral: ?]
רין אויף לנד [?]	[numeral: ?]	[numeral: ?]
רעגנשבורג [Regensburg]	[numeral: ?]	[numeral: ?]
רויטן בורג [Rothenburg]	[numeral: ?]	[numeral: ?]
ראב ד'אונגרי' [Raab of Hungary = Győr]	[numeral: ?]	[numeral: ?]
ריג [Riga]	[numeral: ?]	[numeral: ?]
רעבל [Reval (Tallinn)]	[numeral: ?]	[numeral: ?]
רבת בני עמון [Rabbath-Ammon]	[numeral: ?]	[numeral: ?]

אות ש (Letter Shin) — p. 67

Place	Latitude	Longitude
שפייאר [Speyer]	[numeral: ?]	[numeral: ?]
שאקמיא [?]	[numeral: ?]	[numeral: ?]
שטראם בורג [Strasbourg]	[numeral: ?]	[numeral: ?]
שטיילנבורג [?]	[numeral: ?]	[numeral: ?]

Place	Latitude	Longitude
שדווייץ [?]	[numeral: ?]	[numeral: ?]
שושן הבירה [Shushan the capital (Susa)]	[numeral: ?]	[numeral: ?]
שבא [Sheba]	[numeral: ?]	[numeral: ?]
שכם [Shechem (Nablus)]	[numeral: ?]	[numeral: ?]
שילה [Shiloh]	[numeral: ?]	[numeral: ?]
שוויריידן [?]	[numeral: ?]	[numeral: ?]
שאלונקי [Salonika (Thessaloniki)]	[numeral: ?]	[numeral: ?]

(89§) סימן פ"ט — p. 67

§89. A resolution concerning what our Sages, of blessed memory, said: "Jerusalem is the center of the world."

Even though, on account of the sphericity of the Earth, one cannot posit in it any beginning or end, any up or down, any middle or antipode — since people stand and dwell upon all its various extremities, and in every place where a person stands, there he is upright [with the heavens above him] [remainder of clause uncertain] — nevertheless, we have already explained above [as in §(?)] that the inhabited world extends from the shore of the Western Ocean to the shore of the Eastern Sea, a span of half the Earth's sphere, which is 180 [ק"פ] degrees. The ancient sages set this down [in their works], and all the later ones likewise, [reckoning] the number of degrees and minutes of the Earth's sphere from the [western] shore [text partly illegible]. According to this premise, and with these supports, it is fitting and proper for us to call "the center of the world," or its "navel," that point which lies on the plane at an equal distance between the eastern edge and the western edge — each of them being [?] degrees [away] — such that when the meridian line (the midday circle) running from the northern pole to [the southern pole] passes through that point and divides [the Earth's line] evenly into two parts, and the two [great] circles — namely [the equator] and the meridian — cross upon the aforementioned point crosswise, in warp and woof, extending to the edges of east and west and to the two poles of north and south, and dividing [the sphere] into four equal quarters: then that point alone would deserve to be called the center of the world, or the navel of the Earth. Concerning that place it is proper for us to say that it is set apart from all others, and that there is no other place [of] this measure. [...] This is what our Sages meant [when they said] "from here [the world was founded]," and so forth, and [what is said] in

Midrash Tanchuma [Parshas] Kedoshim [...] — to call [Jerusalem] the navel of the Earth, and thus the center of the world.

And is this not known to us also by demonstration? For in the alignment of Jerusalem, it sits at a longitude [?] of 66 [ס"ו] degrees, and at a latitude of the settlement of 32 [ל"ב] degrees, as [explained] above [text partly illegible — a reference to the science of astronomy (תכונה) and mensuration, and measuring from the equator with a quadrant, "as explained above in Chapter [ב']"]. And so those who teach wisdom and knowledge and understand every matter have repeated this reasoning a thousand times. This is the reason, and for this reason [the Sages] set Jerusalem as the center of the world.

Know that others besides them have already been troubled by this difficulty, and they treated it at length [...]. To resolve this doubt I shall tell [you] in a few words [what was said] above: it is known that the inhabitants of the world dwell in only about a quarter [of the globe], and the ancients already divided it well into seven [climates], as in §66[?]. Now behold, the Sages — natives of the city of Jerusalem — [held that] it sits among the climates, [dwelling] between the two [extremes]; for it is a mean between the cold and the heat, and therefore its climate is more temperate than the rest of the airs [regions] of the world.

**

(continued on p. 68, right column):...for on account of the predominance of the southern [heat] and the predominance of the cold opposite it in the north, the people [of those regions are darkened / of a different complexion] [text uncertain]. And I have already found in the words of the Sage (Rambam) [parenthetical gloss in source]: "[a wise man may be found] in the land of Kush..." [remainder uncertain]. [...] All these things the Sages intended in their saying "Jerusalem [is the center of] the world" — that is to say, the center [of the inhabited region]. The latitude of the settlement [...].

[Bold paragraph-initial, reading uncertain — תרע(?):] For such indeed was their intent, since they compared it [the Land] to a navel, as they said in Midrash Tanchuma [Parshas] Kedoshim: "Just as the navel is set in the middle of a person, so [the Land of Israel] is placed in the middle of the world" [...]. [Just as the navel] is set in the middle of one's body [...] [remainder partly illegible — cites "the LORD shall reign forever and ever" (Shemos 15:18 / Tehillim) as a sign of that which is without end]. [...] This is what the Sages [meant] in saying "Jerusalem [is] in the middle" — meaning the middle of the settlement, as above.

(§90) סימן צ — p. 68

§90. A resolution concerning the saying of our Sages, of blessed memory, that "the Land of Israel is higher than all lands."

There is also room to wonder at what the Sages said in the chapter "Asarah Yuchsin" [Kiddushin ch. 4] [regarding] the verse "And you shall arise and go up [to the place]" (Devarim 17:8) — from which [they derived] that the Temple is higher than all [of Eretz Yisrael], and that the Land of Israel is higher than all lands. [...] For it cannot be said that it is [physically] higher on the sphere, since for every person, in every place he sits, there he is level [and upright] [...] [reference to Beit She'an(?)]. If you were to go the way of the researchers [natural philosophers] to say [...] [text partly illegible].

(left column): [...The biblical idiom of "going up" and "coming down" — as in "and they brought up... the king of Babylon," and likewise in Yehoshua — refers not to physical elevation but to honor and rank.] For we already know that in all of it [Babylon] is a low[-lying] land [...], "excellent," and the like [text partly illegible], "as it is said" [...]; Scripture says "and they brought him up," "and they raised him up" — up to greatness and honor [...], for [Joshua and Israel] were there in the valley [i.e., a low place, yet spoken of as "going up"]. So too the Sages said "the Land of Israel is higher" — meaning in rank and honor, more than all lands.

(§91) סימן צא — p. 68

§91. What the earlier ones received [by tradition] concerning the beginning of the 360 [ש"ס; printed הש"ם] degrees for the sphere of the world.

We have already explained above [as in §(?)] that the later ones [said thus and so], and they relied on the science of mensuration; by this they attain the boundary [prime meridian] [...]. They drew, by the reasoning of their imagination, a line [...], and ten degrees further to the west; from there they began to count, and the beginning [of the count runs] from there [...] the [360] degrees of the Earth's sphere, which — being filled out as the sphere of the Earth — [runs] toward the north side [...]. [There are] two kinds of [islands(?)] [...] the aforementioned [...] the city of [Mainz(?)] [text uncertain]. No single line would fill the whole surface of the sphere [...] only the aforementioned line alone [...] the circles of the [Earth(?)] [...] the year [reckoning?] of the aforementioned boundary.

[Editorial note printed in the source, beside the figure:] "This figure belongs to §87, folio [30/37][?]b, in Chapter [2/3][?]."

Diagrams

Diagram. A circular wind-rose / radial figure set into the lower portion of the page (within the right-hand table area). It shows a small central hub from which numerous straight spokes radiate to the circumference, in the manner of a compass-rose or a wind/direction diagram. No legible labels register at this resolution.

- (center): small hub / boss
- (radii): numerous straight spokes to the rim — [labels illegible]

Diagram. A square frame enclosing an inscribed circle with radiating spokes (a wind-rose of directions), set in the lower-left of the page. Directional labels are printed around it. The source captions it as a figure belonging to §87 (see the editorial note above). Readable labels (intercardinal wind-directions):

- מזרחית דרומית [south-eastern]
- אמצע המזרח [middle of the east / due east]
- מזרחית צפונית [north-eastern]
- מערבית דרומית [south-western]
- אמצע המערב [middle of the west / due west]
- מערבית צפונית [north-western]
- דרומית [southern] / צפונית [northern] [remaining labels partly illegible]

השער הרביעי — The Fourth Gate

[Gate-opening rubric, spanning both columns, p. 69] In this gate will be explained the ordering of the units of time — namely years, months, days, weeks, and hours: around what center they revolve, from what source their measure is known, upon what secret they were founded, why the sages divided the measure of the day specifically into twenty-four hours, the reason the days of the week are seven, what pertains to the reckoning of equal (straight) hours and of oblique (crooked) hours, and other matters besides.

סימן צ"ב (Siman 92) — The units of time in general; there are five, beginning with the year and the month

Know that the units of time which reach the ear are, in the general sense [?], five in number: years, months, weeks, days, and hours. Why the year has such-and-such a measure, why the month is as it is, and likewise the reasons for the

remaining units — you should understand that three of them, namely years, months, and days, are governed [ינטלו] by the revolutions of the spheres. Their measure is not directly known to us, nor can we perceive it by sense; no one truly knows it except through the revolutions of the spheres, as will be explained further on. The reckoning of weeks and hours, however, and the basis on which they were established, require much study and reflection, and many have grown weary [in the attempt]. [The three time-units] governed by the revolutions of the spheres are years [?], months [?], and days [?]; weeks and hours are of a lighter [conventional] kind, as will be clarified. First, the measure of the year and of the months:

The year is a period in which the sun revolves in its sphere beneath the circle of the zodiac from a [given] point back to that [same] point — that is, from the moment the sun begins to revolve from point A until it returns to that very same point from which it began — this is called a "year," as will be explained. If the reckoning of the "year" were applied [uniformly], then every sphere would have its own [year], for the time of each sphere's revolution is its "year." I say, by way of illustration: were it to enter our minds to count and reckon the units of time by the revolution of the sphere of Saturn [שבתאי], and were that sphere before our eyes to observe — its period of revolution being such-and-such — then, just as we now say that the sphere of [Mercury? — כירק, uncertain] revolves and renews itself some twelve or thirteen times within the [solar] year, so we would say that within a single "year" of Saturn the [inner] sphere revolves thirty times, and such-and-such a sphere so many times, and another sphere so many. Nevertheless, our holy Torah has already agreed to count and reckon the great and long periods of time solely by the revolution of the sun in its sphere; to it belongs the right of the firstborn, that the revolution be named and reckoned by its revolution alone and by no other star. To this all the ancients and the moderns agreed: that from the time of the sun's departure from a known point opposite the sphere of the zodiac until it returns a second time to that very point — this is called a "year."

(Its measure of time is 365 days and close to a quarter [365¼], as will be explained further on, at the head of Gate 7, in §138. It serves us as a true guide for reckoning, by the time of its revolution, all the other spheres' revolutions in combination with all the other long cycles beneath the heavens — because it is more fitting and correct for us than any of the other spheres' revolutions: for it is in the annual cycle of the sun that the measure of the length [חורכי, uncertain] of the days and nights, the seasons of summer and winter, and the seasons of all the

ripening [?] of fruits, all recur in their combination — these times that recur again and again.)

סימן צ"ג (Siman 93) — That the sun has no "month" at all, and the moon has no "year" at all

We are still speaking of the matter of the sun and of the renewal of the moon; it is fitting, before proceeding further, to clarify the three [units] called weeks, days, and hours, at the proper place. This is a matter for our sages — that the sun has no "month" and the moon has no "year" — for there is need and benefit in it for the students.

Know that the sun has no "month" at all, for renewal [chiddush] belongs specifically to the moon, as has been explained; and for this reason it is called *chodesh* [month], which is from the language of *chiddush* [renewal]. This applies [וליחנה?] only to the moon, which renews itself, as Rashi of blessed memory wrote in chapter [22? — כ"ב] of [Rosh Hashanah?], fol. 21a [?]. And so too the sage Ralbag [Gersonides] wrote in his discussion "of the World" [בפ' העולם], and these are his words: nothing is renewed in accordance with its name except the renewal that gives power to the light of the moon; for this reason it is called *chodesh* — which is not the case with the revolution of the sun, in which nothing is renewed. And even though we find in the course of the sun four distinct motions, as will be explained further on in §181, nonetheless no trace or sign of the measure of a "month" is found in it: [the interval] we mark in it, from the time of its departure from a known point until it returns to that point a second time, is the sun's "year," not a "month." The sage Ralbag also wrote in his discussion "of the World," and others [wrote likewise, that] this is called [a year? — text garbled: ואלתסטמפני… שנא ספרוגו] "a year" a second time, from the language of [Melachim II, ch. 18? — סנו וישגו דמלכים ב', see 18 [?]] — which is not the case [with a "month"] at all, as will be explained.

As for what people say, "the months of the sun" — R' David Abudarham [Abudarham] wrote that this is by way of borrowed usage: the term is borrowed from the course of the moon, for although the sun has no renewal at all, they nonetheless called a twelfth part of the year a "month." And the sage Ralbag wrote in his discussion "of the World" that, since the moon renews itself twelve times each year, they divided the year into twelve parts and called each part a "month," because [each] approximates the days of the lunar month — not because there is any [renewal] in the sun's revolution that divides those parts in

actuality, nor because the moon renews itself within each such month, as [he] states elsewhere, [each part] being 1/12 of the year [?] —

סימן צ"ד (Siman 94) — On their natural times, which are reckoned "from period to period" [the 24-hour natural day]

The natural days (that is, each day combined with its night), which are before us, [are what] is called a "natural day," as [explained] just above, in §160 [?]. [The days] are not [reckoned] by the revolution of the moon's sphere; rather, the natural days are governed by the motion of the daily sphere: from the moment the sun begins to circle the globe of the world by its daily motion, until it returns to that same place from which it began to circle — this period is called a "natural day." Thus we reckon the beginning of the day from one of the degrees [rising], with the four [additional] "moments" that were spelled out, as stated in §105 [?]. Behold, from one period to the next is [about] 24 [hours] of the units of time, until [the sun] returns to it a second time by the daily motion — [this] recurs, according to the sages, as a "natural day." [It is] a little more than the circuit of the daily sphere, close to one degree [more], as will be explained further on in §[cross-ref, unclear].

But bear in mind: these three units of time — years, months, and days — are governed by the revolutions of the spheres. Therefore, just as no human being has the power to lengthen or shorten the motion of the spheres, so too there is no room, no opening, and no possibility whatever to imagine lengthening or shortening these times. Hence one should not ask why the measure and time of the year is thus, why the measure of the month is thus, and the measure of the day thus. As for the reason for the numbers and times of the days of the week, and likewise the reason for the number of the hours of the day — that requires much study and reflection.

סימן צ"ה (Siman 95) — On the times of the day's hours, and on what their foundations were established

Know that the times and number of the hours, of which there are 24 in a day, constitute the fourth kind of time, added to the three kinds already mentioned. This kind of time we do not find anywhere in Scripture, nor can it be attributed to the motion of any sphere, as could the three chief kinds of time mentioned. Therefore know that the hours are conventional times, not times founded [in nature]; they are but parts of the day. The sages had the authority to divide the day as they saw fit, into many parts or few, more or fewer than 24; but they chose

to divide it into 24 parts, for a reason to be explained shortly, and called each part an "hour." [This is] not because the sphere fixes [these] times of hours as it does one of the three natural time-units; rather, the sages did this as a [deliberate] act.

Know that the numbers of the days of the week and the numbers of the hours of the day — indeed, [also] the reckoning of the hours of the day — were a great and constant perplexity to us: why, and for what reason, did the ancients fix specifically the number of the days of the week at seven days, and the number of the hours of the day at 24 — when we would seem to have an opening to say that the hours of the day might have been fixed at more or fewer than 24; and still more of an opening to fix the days of the week at six days near it, since by [the criterion of divisibility] it would have been more fitting for the number to be divisible by half and by quarter — and [six] is also divisible by half and by third.

(Moreover, the number six is one the sages already treated, and they called it a "perfect number" [מספר שלם], since a wondrous property is found in it: all the divisors of this number add up to the number itself — namely its half, which is three; its third, which is two; and its sixth, which is one — which together sum to exactly the number itself. This is not so with the other numbers: no perfect number is found except among the units [6], among the tens [28 — printed form garbled], among the hundreds [496 [?] — printed ɜematria unclear], and among the thousands [8,128 [?] — printed unclear]; and there are no others [below ten thousand]. We have already given some explanation of this at the head of our book [§4:4? — 'נסי' ד', reference uncertain].) The number seven, by contrast, admits of no divisor at all.

And beyond all doubt, the fixing of the number of the natural day's hours at 24, and of the days of the week at seven days, is not without a fitting reason in each case. What I have found concerning this — incline your ear and hear. You will grasp the reasons for the [number of] hours, their basis, and their placement; and by that means we will arrive also at the reason for the days of the week.

Know that the times and number of the hours, of which there are 24 in a day, are [something the astronomers established]. The astronomers agreed to divide each and every hour into 60 parts, called "minutes" [דקים] of the hour, or "seconds" [שניות]; each minute into 60 "thirds," and so on into fourths, fifths, sixths, and onward down to tenths. And there is surely no doubt that the fixing of the numbers — the natural day at 24 hours and the days of the week at seven days — is, in each case, not a conventional time without a fitting reason.

The astronomers reckon the times of the hours specifically by the revolution of the equator [המישור], because it always revolves at a uniform rate and over one uniform arc, which is not the case with the daily [zodiacal] sphere, which sometimes revolves 22 degrees [כ"ב] in an hour and sometimes 18 degrees [י"ח], as will be explained further on. And you should know: since they divided the day into 24 parts, [dividing] the 360 degrees of the sphere by 24 gives each hour 15 degrees [ט"ו], so that in each hour the equatorial sphere rotates about 15 degrees along the meridian above the horizon. We say "about," because the daily sphere revolves each day slightly more than one complete circuit — by close to 1/[360] of the sphere's parts [i.e. about one degree per day] — as [explained] further on, in §160 [?].

סימן צ"ו (Siman 96) — The reason why the measure of the natural day [is divided] into 24 parts

As for the sages' having divided the measure of the natural day into 24 hours: the plain reason is that this number possesses [convenient] divisors — a third, a quarter, a fifth, a sixth, an eighth, and a twelfth [?] — which is not the case with the other small numbers. Beyond this, know that I have found another reason, fine and sweet to the palate. Since the ancient sages of inquiry, from earliest times, and those who grasped the ancient [traditions], apprehended for a firm and remembered [purpose] the mystery of the seven planets — **שצ"ם חנכ"ל** [the mnemonic: **Sh**abtai (Saturn), Tze**d**eq (Jupiter), Ma'a**d**im (Mars) / **Ch**amah (Sun), **N**ogah (Venus), **K**ochav (Mercury), **L**evanah (Moon)] [printed שלש"ם חנכ"ל, garbled] — each one of them "reigns," one after another, over one part [hour] of the 24 in a day. Thus they rule one after another and exchange their dominion each natural day among the 24 periods, in such a way that [the sequence] fills out the mnemonic-signs for the "heads of the nights" of the seven days of the week (כ"ז נג"ם חל"מ [?]) and the mnemonic-signs for the "heads of the days" (חל"ס כלנ"ם [?]), as will be explained shortly. In this way [the sequence] recurs perpetually, world without end. All of this could not have worked out, nor could their reckoning have been made to fit, except by dividing the natural day into twenty-four parts.

סימן צ"ז (Siman 97) — The reason for the days of the week being seven days

And so, by this very reason, our holy Torah fixed for us — [Torah] given by the Blessed One — the measure of the days of the week at seven days: "Six days you shall labor, and the seventh day is a day of rest" [cf. Shemos 20:9–10]. For within

this period of seven days, which is 168 [24×7 = ,קס"ח] natural hours, the seven planets complete their perpetual cycle, each returning to the place of its rule that it held at the outset; seven times 24 amounts to 168, and they recur perpetually — [the mnemonic] כלנ"ם / חל"ס for the "heads of the nights," and חל"ס כלנ"ם for the "heads of the days," through all the days of the world.

The ancients gave a mnemonic for this: (ח"ס כ"ל פ"), meaning "Kochav [Mercury] — night; Chamah [Sun] — day," that is: the first hour of the night of the first day — which is the eve of Shabbos [Friday night] — the rule of the sun begins; and this is [the sign], meaning "Chamah [rules the] day." In this fashion they recur perpetually, through all the days of the world.

And although we are not compelled to rely on the reasoning of the sages of inquiry rather than on the words of our holy Torah — nonetheless, I found written in the book *Mekor Chaim* [of R' Shmuel Tzartza?], on the portion of Bereishis, quoting the sage Ralbag, and these are his words: "Know that Moshe, peace be upon him, gave the Torah not to the wise-hearted alone, but to every generation and age; and our sages relied on the words of Moshe, who provided many signs and wonders that he was the messenger of God, adding nothing and subtracting nothing — [so] the words of the men of inquiry were sufficient for us [only insofar as] their view accords with the words of Moshe, and one may rejoice in them" — end of quotation. How eloquent are the words of that sage, of blessed memory.

And it was from this same reason [mentioned] that all the nations of the uncircumcised, under all the heavens, though they have no share in our holy Torah, willed to fix the days of the week at seven days [?] —

[סימן צ"ז, continued — p. 71, left column]

— [seven days] equal and whole; [and though] the number of eight days [would have divided evenly, and] by appearances a more fitting cause [for a smaller count exists], for the reason I wrote just above [i.e. divisibility], nonetheless they too chose to count the days of the week as seven days, since this number [seven] admits of no division whatever — chiefly because of the choice of seven days to correspond to the seven planets, which recur perpetually every single week, world without end, as above.

סימן צ"ח (Siman 98) — A table for the rulership of the planets — of the seven planets — in every hour of all the days of the week

I saw fit, to satisfy the youths' desire to understand the matter, [to provide] a fixed table [לוח], from which the students may know — without any need for study or reflection at all — the rulership of each planet in every single hour of all the days of the week; and just as it operates in one week, so it operates in [every] week, and so it recurs perpetually through all the days of the world. The benefit of the thing is great; from it, too, many sayings of our Sages of blessed memory will become clear, as well as some of the reasons for words in the Torah. See the words of the sage Ralbag on the verse "Remember Shabbos day to sanctify it" [Shemos 20:8], and also [the] *Mekor Chaim* on the verse [בצדק תשפוט עמיתך, "in righteousness shall you judge your fellow," Vayikra 19:15]; and this is not the place to expand. (See also my [book] *Ma'or Katan* [?, the author's own shorter work].)

Know that in matters such as these — that is, the reckoning of the hours by the seven planets — the sciences have already been employed from earliest times, and those who grasped the ancient [traditions], particularly the peoples of Ashkenaz [the Germans]. And it should be noted that the days of the week are named in their language after the seven planets, each one after the star that rules the first hour of that day. How so? The first day — on which, in its first hour, the planet of the Sun rules — is called **Sonntag [זונטא"ג]**, meaning "Sun-day." The second day, named accordingly, is called **Montag [מונטא"ג]**, meaning "Moon-day." The [third] day is called **Dienstag [דינשטא"ג]**, meaning "day of service [?]," on which, on the third day, they used to worship the planet Mars [Ma'adim]. The fourth day is not named after a star, but **Mittwoch [מיטוו"ך]**, meaning "mid-week." The fifth day is called **Donnerstag [דונרשטא"ג]**, meaning "day of thunder," concerning the matter that the planet Jupiter [Tzedek], which rules at the start of the fifth day, governs thunder and lightning. The sixth day is called **Freitag [פרייטא"ג]**, meaning "day of weddings [?]," because the planet Venus [Nogah] governs love, joy, betrothals, and marriages. Shabbos day is called **Sonnabend [זונאבנ"ט]**, meaning "eve of the Sun-day"; and in many places, especially in the provinces of [Saxony? — וכסין] and Carinthia [?, קורינלנ], it is called [Sater-tag? — קארטע"ם טא"ג], meaning "Saturn's day [Saturday]," because Saturn [Shabtai] was called **Saturnus** [סטיר"נא].

סימן צ"ט (Siman 99) — That the time of each planet's rule, of the "wandering" [?] planets, is not only in the first hour of the day, but it rules a whole day

Know that in reckoning the rule of the wandering [?] planets, at first inspection there is great perplexity for us, because their daily rule is the same for all the inhabitants of the earth: for when the sun rises above the horizon for those at the eastern edge — by way of illustration, on the first day, in which the planet of the Sun rules, granting them the first hour — at that very time and moment [it is] the onset of night for those at the western edge, and even more [continues]. This perplexity — great and deep — [is resolved as follows]: [only] if we could pin down and specify [it would be difficult; but] this problem is explained further on, in Gate 8 [?], §214. As for us, we need [only] to know for which place this reckoning was founded, and each person would [otherwise] have needed to compute the natural hour [and] which hour it is at his own location. [But] know that I put the matter before **Johannes Kepler** [יוהנו"ם קעפפלירו"ס], according to the position of [his] place, and he answered me that for this reckoning we have no need to know for which place the reckoning was founded — because of what the astronomers said: that at the first hour one kind of the rule of the planet of the Sun [applies], meaning that the Sun does not rule in the first hour of that day alone, but its rule extends over that whole day, from its beginning to its end — only not over one [single] place; for as its revolution around the globe of the world, so is the measure of its rule, since at every place where it rises above the horizon, there, at that place, it rules for one hour, until the completion of the 24 hours in which it circles the whole globe of the world.

So, when the sun rises for those at the eastern edge — where it rules from the beginning of its rising until the completion of one hour over that place — and as it moves away from there, by way of illustration by just one degree [so that it is now] rising to the middle of the firmament [?] above the horizon, its rule [there] begins from its rising there until the completion of one hour; and such is its rule that whole day. Just as [this holds] for the Sun, so the same rule [holds] for the Moon, specially assigned to the second day [Monday], and likewise for all the rest of the seven wandering [?] planets: each of them rules 24 hours per day, one after another, over the circuit of the globe of the world.

And know [further — as Christianus (?), meaning] you should understand that the rule of the planets is not the same for all the inhabitants of the earth, but [only] for the climes that share the same longitude — that is, those whose dwelling-

places [lie] along the same [meridian] line running from north to south, all of whom share one [and the same] meridian ["midday" line]. And yet know that even for people who share the same longitude, if they are far from one another [in latitude], the rule of the planets is likewise not the same for them, [this being] on account of the precedence of the sun's rising for the more northerly over the more southerly, as [explained] further on, in §132. This too is a deeply intricate matter — nonetheless, [resolved in its place]. Every place of the world begins each day to be called by its own [planet's] name, as [explained] in Gate [?], §160 [?]. This too was the intent of this reckoning — the rule of the planets — and in its [proper] place it shall stand.

סימן ק' (Siman 100) — On the reckoning of the equal (straight) hours, [and] the equal ones apart from them

The equal (straight) hours require no lengthy explanation, since it has already been made clear that the sages divided the measure of the natural day into 24 hours, in each and every one of which the equatorial circle rotates 15 degrees — as these matters will be explained further on, in Gate 8, §§142 and 143. But the reckoning of the oblique (crooked) hours has a different law and rule, as will be explained shortly.

You should know that the astronomers reckon [from] the beginning of their day until midnight always as 12 hours, and likewise from midnight until midday, again 12 hours. Upon this reckoning the ancients founded for themselves the hour-indicators [the striking clocks and bells — המורה־שעות, הפעמונים] that sound the hours: from midday until midnight, 12 hours, and from midnight until midday, likewise 12 hours. In particular, those who reckon the [calendar] intercalation — the inhabitants of [Rhineland? — רינו"ס], who reckon by the equal (straight) hours — must set the head of the day-count from the onset of the night, as will be explained. They also require [an explanation of] the 12 hours of day and 12 of night throughout all seasons of the year, as all the halachic authorities have written: they reckon in this manner, always beginning each night at [six? — משעה] hours after midday, and beginning the day at six hours after midnight, in all seasons of the year — summer and winter, [heat] and cold — whether [the day] is advanced or delayed, whether the daylight or the night is long, [of] the aforementioned periods. We have already given a fuller treatment of this in [my] *Ma'or Katan* [?], in the gate on [—], together with what we wrote about the great difference in this reckoning between the inhabitants of [—, R... (?)] and the inhabitants of [—, Fiess? (?)] and Poland [ופולין] [—]. [Text garbled at column foot.]

סי' קנ"א (Siman 101) — On the reckoning of the oblique (crooked) hours, called "temporal" [seasonal]; they are always 12 hours in the daylight and 12 hours in the darkness of night

Know that the reckoning of the oblique (crooked) hours is this: always, in every place and at every time, one divides the measure of each day — from the time of the sun's rising over the earth until [its setting] — into 12 parts, and likewise the night into 12 parts [reckoned by] the sun [passing] beneath the earth, again 12 parts — whether the day or night be long, or the day or night be short. The rule in all cases is the same. For example: at the summer solstice [tekufat Tammuz], for the inhabitants of the city of **Prague** [פראג], the [daylight] arc rises above the horizon 240 degrees [ר"ם] of the equal circle, which is 16 equal hours [ט"ז], reckoning 15 degrees per hour as above. But when we divide the aforementioned measure of the day into 12 parts, we must divide the 240 degrees into 12 parts, yielding long, oblique hours: each hour amounts to 20 degrees, which is one and a third equal hours. Thus each oblique hour is longer than an equal hour by a third of an equal hour. And likewise the measure of each night is divided, each [night] into 12 [parts].

Even though the reckoning of these oblique hours is strange in the eyes of the young students, know that upon this reckoning all the sages agreed, ancient and modern alike, whether of the Children of Israel or of the nations of the world — both in the reckoning of the intercalation and in the other calculations. All of them agreed upon [this reckoning — continues in the next section].

for the reckoning of the temporal hours, as will be explained further just below.

You should also know that — as I already explained above, in §34 — for people who dwell beneath the equator [קו השוה], the measure of day and of night is always equal for each of them, twelve hours each. Those people, therefore, have no difference at all between the equal (straight) hours and the temporal hours. Only those who are tilted [in latitude] and dwell off the equator have temporal hours [that differ]. Know, too, that every group [of inhabitants] has its own temporal hours: the hours of one place are neither identical nor equal in their measure to the hours of another place. For all who dwell along one straight line [meridian] running from east to west, there is no difference except in precedence — those to the east are earlier, those to the west later — as will be explained below, in §150 [?].

These hours of which we have spoken are called [?] "temporal hours" [שעות זמניות], that is, seasonal hours; for in every season, throughout all the days of the year, the measure of the hours changes in the world for all who dwell beneath [a given latitude]. Since a person dwelling in one place has the measure of his hours changing each day according to the measure of the length of the days, the measure of one day's hours is never equal to the measure of the following days' hours throughout the whole year. It never happens that temporal hours coincide with the equal hours during the whole year except twice a year — namely, at the seasons of the equinoxes of Nisan and Tishrei, when day and night are equal for all the inhabitants of the world in every clime.

(§102) סימן ק"ב — On what basis the reckoning of the temporal hours was established

Know that for all the inhabitants of the world, in every clime, six signs of the zodiac are always [above the horizon] during the time of daylight and six signs during the night, neither more nor less [?], whether the day (or night) be long or the day (or night) short — and the seasons of Tammuz and Teves are equivalent in this regard, as will be explained to you further on, in §115 [?]. Know, then, that the scholars of this science agreed to reckon [?] in this configuration: since fifteen degrees [ט"ו מעלות] pass across the meridian for each equal (straight) hour, so they reckoned the motion of all six signs, which span 180 degrees [ק"פ מעלות], as making up the twelve [temporal] hours — so that the degrees are always divided fifteen to an hour [in ecliptic terms]. In this way, when the daytime is reckoned as twelve hours and the nighttime as twelve hours, at the two seasons [?]... the difference between the measure of day and of night is great; and correspondingly the difference in the temporal hours is called great. For in winter the degrees of the signs [rising] during an equal hour exceed the degrees of the signs [rising in a temporal hour], and in summer the matter is reversed. That is: at the season of the Teves [winter] solstice, which is the shortest day of the year, nonetheless, since only six signs — 180 degrees — ever rise above the horizon on that day, when we divide those 180 degrees by twelve, each temporal hour comes to fifteen degrees [ט"ו מעלות], which is one-twelfth [חלק אחד מי"ב] of the measure of daylight; for 180 degrees divided among twelve [hours gives fifteen each]... only two-thirds of a [short] hour [?]...

[Continuation of §102, top of the left column:] ...[to complete the temporal hour] we need only twenty-two and a half degrees [כ"ב מעלות ומחצה, recte for ל"ב as printed?] of the degrees of the signs; for when we divide the 180 degrees of the sphere by the number of the [equal] hours of that day — which are eight [שמנה

שעות, i.e. the short winter day] — we obtain 22½ [?] of the degrees of the signs rising at that moment during an equal hour. And on the day of the Tammuz [summer] solstice, which is the longest day of the year, nonetheless — since no more than six signs, which are 180 degrees, ever rise above the horizon — when we divide those by the number of that day's [equal] hours, which are sixteen [ששה עשר], you obtain 11¼ degrees [י"א מעלות ורביעית] of the degrees of the signs [per equal hour]. And as the rule is for the day of the Teves solstice, so is the rule for the night of the Tammuz solstice; and as the rule is for the day of the Tammuz solstice, so is the rule for the night of the Teves solstice.

(103§) סימן ק"ג — That the reckoning of the intercalation — the seasons [tekufot] and the conjunctions [molados] — was established according to the temporal hours

Although the reckoning of the temporal hours is what turns and recurs constantly for most of the world, so that [?] this reckoning is not [otherwise] grasped in every place — nonetheless, know that it was according to these temporal hours that our early sages of blessed memory established for us the whole reckoning of the seasons [tekufot] and the conjunctions [molados]. Likewise, all the other "hours" mentioned in the Mishnah are temporal hours, as several great authorities among them attested — such as Rambam of blessed memory, in the first chapter of [tractate] Berachos, and these are his words: "Know that all the hours mentioned throughout the Mishnah are the temporal hours; and the meaning of 'temporal' is the hours of which there are twelve by day and twelve by night." And what he said, "until [a certain number of] such hours are completed," means until the end of a quarter of the day, whether it be the day of the Tammuz solstice or the day of the Teves solstice — thus far the words of Rabbeinu Ovadiah of Bertinoro [ר' עובדיה ברטנורא], and he set down his words [likewise?]. The Israeli sage [Isaac Israeli] also wrote so in his book *Yesod Olam*, essay II, chapter 7, and again in essay IV; and Rabbi David Abudarham [ר' דוד אבודרהם] likewise wrote so at the head of his "Order of Intercalation"; and so, apparently, is also the view of the author of the *Shem[?]* [?] in the matter of §46 [?], and of the *Tur*, *Orach Chaim*, §428 [ת', recte תכ"ח?].

Know, then, from now on: when the reckoning yields for us that the Tammuz season falls — for example — at seven and a half hours [ז' שעות ומחצה] into a given night, know that those are seven and a half *temporal* hours, which, according to the reckoning of the equal hours, mean that this season falls for us, the inhabitants of Prague, at five hours [ה' שעות] into the night. Likewise, when

the conjunction [molad] of the month of Teves, or its season, comes upon us — for example — at ten and a half hours [עשר שעות ומחצה] into the day, this conjunction or its season will be, by the reckoning of the equal hours, seven hours [ז' שעות] into the day; and from this [proceed] to the rest of the times in the manner of reckoning by temporal hours.

Know further that these temporal hours were called by the sages of the nations "the hours of the Jews" [שעות היהודים], since they were [in use] for the Jewish people when they dwelt on their own land; and to whoever writes [of them]. I have seen in books [?] narratives of events that occurred in Jerusalem during the time the Temple stood, in which many deeds at various times are reckoned as "at the close of the sixth hour" [being] the end of the day, or "at the close of the twelfth hour" [being] the end of the day — from which it apparently follows that in that period the Jews reckoned their hours by temporal hours, for we say [?] that all those deeds were done specifically in the seasons of Nisan and Tishrei [when temporal and equal hours coincide].

I have further seen fit to inform the reader that these temporal hours are called, in accordance with [?] the hours of the seven planets [שבע המשרתים] — that is, the [planetary] hours of the seven planets [שבעה כוכבי לכת]. For just as the rule with the signs is that there are twelve temporal hours [rising] on the horizon in every time and place, so is the rule with the seven planets — because Ptolemy [שבטלמי?] and [Nasibutis?] [?], author of [?], hold that [the planets] are always beneath the revolution of the signs, as will be explained further on, at the beginning of the Fifth Section, in §108 [?]. Accordingly, just as there is a rule for the risings and settings of the signs, so there is a rule for the setting [and rising] of each one of the seven planets. The illustration of this: when, say, the star of Saturn [כוכב שבתאי] completes [its passage] beneath the head of the sign Cancer [ראש מזל סרטן], the rising and setting of that star follow the revolution of the daily sphere in the rising and setting of that sign itself. (However, I do not know why they were not called "the hours of the signs"; and the reason and benefit [of the term] "temporal hours" will be explained to you somewhat further on, in the Eighth Section, in §[?].) With the help of God.

(104§) סימן ק"ד — On the cause of night, and the shadow of the earth [ומצל הארץ]

The cause of night is already known even to those just weaned from the breast [עתיקי משדים; cf. Yeshayahu 28:9]: when the sun sets beneath the western horizon, its light is withheld from us, and the absence of light is the darkness, which is

night. Yet even so, we still have something to say, and we shall speak here about [the light and its removal, which is] the cause of night. Know that after the sun has set, [it goes on illuminating around] the surface of the earth — which is entirely round, its base below, in the breadth of the sphere of the earth. And considering the ratio of the size of the [eighth?] sphere [כדור השמיני, i.e. the sphere of the fixed stars] [?] to the smallness of the sphere of the earth — which is a [mere] point in relation to the heavens, as will be explained further on, in §[?] — behold, the shadow [of the earth] goes on [tapering] until it returns to a point [and the stars…] [text degraded]; … [that shadow] is so high and lofty that it is wondrous [?]; … and it passes through the whole thickness of the sphere of Mercury [?] and enters within the sphere of Venus [גלגל נוגה], by some [amount of] parts of a mile [?]; and within the sphere of Venus the [shadow] is entirely dissipated [?]. … [And this shadow] is what is cast over us so that we abide [in it] at night; and by this shadow, [there is] no [surface?]… over the whole world; only [the sun] itself revolves around the sphere of the earth, together with the motion of the [daily sphere]. So, in accordance with the [motion of] the sun, so goes the revolution of the sphere, returning in cycle forever; … the points of the world [tevel] [remain?] fixed opposite the signs at every moment; … the sun [?]. This matter shall be to you a reminder [when] you consider these things elsewhere. See further on, in the Ninth Section, §241 [רכ"א, recte רכ"ד?], and there you will find [the position of?] the sphere and the star[s], as it is written [?]. With the help of God.

(105§) סימן ק"ה — The meaning of the word "day": the distinction between a working [artificial] day and a natural day, and from what time it begins

This matter we already explained in our book *Ma'or HaKatan*; nonetheless [I will explain it here again, for in this too there is benefit].

Know that the word "day" [יום] is used in three senses. The first: it is said of the time during which the sun rules above the horizon — in the sense of the verse, "day and night shall not cease" [cf. Bereishis 8:22], where "day" is distinguished from "night." This span the scholars call the "working day" [יום מלאכה]. The second [sense of] the word "day" is said even of the night, as in "on the day [He] smote every firstborn" — for this was at night, as it says, "and it came to pass at midnight, and Hashem smote every firstborn" (Shemos 12:29); and likewise, "by day I cried out, [in] the night, before You" (Tehillim 88:2), whose meaning is [the whole span of] time. Specifically the time the sun is over the earth is called "day,"

as the sage Ibn Ezra [רחב"ע, recte ראב"ע?] explained on the verse "the pillar of cloud did not depart by day" (Shemos 13:22). The third [sense]: the word "day" is used for the time of the working day together with the night that precedes it, as in the verse "and it was evening and it was morning, day one" (Bereishis 1:5), whose meaning is that the evening together with the morning constitutes "day one." This span our scholars call the "natural [day]" [יום טבעי], and in the Latin tongue they call it "diem naturalem" [דיהו"ם נטוריאל — Latin: diem naturalem, "natural day"]. Most [occurrences of "day"] mentioned in the Torah without mention of night mean the natural day.

The natural day has no fixed [obligatory] time set for its head and beginning — only four reference-times [ד' זמנים], of which four [?] are fit to be set as the head and beginning of the day. The first time is sunset, which is the end of the day that has passed and the beginning of the day to come; and this is [the beginning] according to the consensus of our Torah, as will be explained. The second time is [mid]night, and to this some of the scholars agreed, according to the course of the stars. The third time is sunrise from the direction of the east; and accordingly the night that comes after it follows and extends after the day that has passed. This reasoning, too, is found in our holy Torah, regarding the beginning [of the day] — as with the thanksgiving peace-offering [shelamei todah], of which it says, "on the day it is offered it shall be eaten; you shall not leave any of it until morning" (cf. Vayikra 22:30). The fourth time is the moment of midday [חצות היום], and to this most of the astronomers agreed, for a reason to be explained further on, in §134 [?]. … [Shabbos day, for instance, is reckoned to begin with part of the sixth day…] some equal [?] hours earlier; and the time [set] by the consensus of our Torah [differs from that of] the astronomers, [who set] the beginning [of the natural day] on Shabbos day — for example — [such that] there is a difference of eleven hours [י"א שעות] between our reckoning and yours [?]; [and one who does not distinguish this] has not spoken correctly.

So you have four reference-times in the natural day, at each of which it would be fit to set as the head and beginning; nonetheless, know that our holy Torah agreed that the reckoning of the beginning of every day shall be specifically after sunset, which draws on the beginning of the night. The sage Ibn Ezra [רחב"ע, recte ראב"ע?] already wrote, in Parshas Yisro, on the verse "from the morning until the evening" (Shemos 18:13–14), that the true evening is at sunset. And all the astronomers admit that the day [runs] from sunrise until [this point].

Shabbos and the festivals, by Torah law, enter from when the sun sets; only the Sages added [some] of the profane to the holy: at the entry of Shabbos, [its onset]

shall be before sunset, and at the exit of Shabbos, [its close] shall be after the stars come out. And the reason, as the sense of our Torah [conveys], is to begin every day after sunset — [as] the Israeli [Isaac Israeli] wrote in chapter 16 [?] of the third essay [of *Yesod Olam*]. For [the festivals depend on] the new moon [chodesh la-levanah], and we compute to sanctify them by the sighting of the moon at its renewal; and where is the new moon first seen? Only at the beginning of the night. Therefore, by law, the days of the month begin at the beginning of the night; and since each of the festivals depends on the beginning of the month and its start — as it says, "in the first month, on the fourteenth day" etc., "on the fifteenth day of this month" etc. — therefore

[the beginning of] every festival will begin, by reckoning, [at night], and it too begins at night. For this reason Scripture bounds Yom Kippur at its beginning and its end, when it wrote [the command] and made it a paradigm [binyan av] for the other Shabbosos and festivals — to say, "from evening to evening you shall keep your Shabbos" (Vayikra 23:32); and likewise you find [that] Scripture wrote, like us, "in the evening you shall eat matzos," with the day of the fourteenth [יש ;ד"י?] of the month, in the evening (cf. Shemos 12:18).

(106§) סימן ק"ו — On how the time of the natural day exceeds the measure of the time of one revolution of the daily sphere

It is already explained above that from the revolution of the daily sphere the measure of day and of night comes about, whose number [appears] at first glance [to make] the measure of the natural day and the measure of the daily-sphere day one and the same time entirely. But know that, in essence, the matter is not so. For if the sun stood in one place, without moving from it, then the measure of the time of one revolution of the daily sphere would indeed — without any addition or subtraction at all — equal the measure of the natural day. But since the sun revolves nearly one degree [קרוב מעלה א'] each day ... [nearly one degree] in the sphere, as will be explained further on, in §165 [?]. Blessed is He who nourishes me, sustains me, and satisfies me [ברוך זנני פרנסני ומשביעני].

[Elaboration of the same, in the left column:] ...And this revolution [is such that] the daily sphere revolves each day slightly more than one complete revolution, by nearly [one part?] of the parts of the sphere [?], and so the natural [day] exceeds the time of the daily rotation. For example: at Nisan [the spring equinox], the center of the sun rose together with the head of the sign Aries [ראש מזל טלה] on the horizon; so, when the head of Aries revolves the next day, at the setting of

the daily sphere on the horizon a second time, the sun has [not yet] returned there — for the sun's [own] portion has already [moved on] during the [previous] revolution of the daily sphere, along its first course, by nearly one degree of the sphere's daily motion. Because of this, the sun does not rise on the horizon until the daily sphere revolves a further nearly one degree. It thus emerges, accordingly, that the daily sphere revolves, over a full day [מעת לעת] — that is, from the [true] east at the [start] of the day until the sunrise of the next day — one complete revolution plus, in addition to it, nearly [one part / a fraction] of the degrees of the sphere [?]; and accordingly the measure of the natural day exceeds the time of one revolution of the daily sphere by [that fraction], approximately. And it is "approximately," because the sun, in its own course, does not revolve a full degree each day, but only about [a certain number of] minutes [דקין], as will be explained further on, in §160 [?]. So I conclude at the end of the Fourth Section [שעורני בסיום שער הרביעי, transcription uncertain].

השער החמישי (The Fifth Section)

On the breadth of the belts of the zodiac and the shapes of the signs themselves; that they are reckoned in two ways; that the signs are reckoned according to four considerations [ד' בחינות], with an explanation of their ascensions [מצעדם]; (and that the degrees of the signs are reckoned according to four considerations); that six signs rise on the horizon and six set — that the signs, in rising on the horizon, are "girded" [in order], Taurus before Aries and Aries before Pisces; that over many years the position of the whole host of heaven changes for us; together with other matters particular to it.

(107§) סימן ק"ז — On the belts of the zodiac and their shapes, and why they were called by their known names

It is already explained, in the mathematical science, clearly and by demonstration, that most [geometric points] are of a fineness that has no measure at all: even thousands of thousands of points [נקודות] cannot combine to make a line. Likewise, in accordance with their great fineness, [a line] has no breadth at all: even thousands of thousands of lines cannot combine to make of them a surface. For points and lines are only markers of a boundary [and have no extension]. So you should know that in all the aforementioned circles of the sphere, none of them has any measure of breadth at all — not even as much as the point of a needle. Nonetheless, know that the astronomers gave the zodiac circle a breadth of twelve degrees [רוחב י"ב מעלות] in the sphere; and the later

sages, who were more precise in their measurements, added to the first measure until they gave it a breadth of [?] degrees, for a reason that has been explained — [namely,] so as to encompass within a circle of such breadth [all that is needed]. They called it "the belts of the zodiac" [חגורות המזלות], and in the Latin tongue they call it "zodiacum" [Latin: zodiacum]. The line at its middle, which divides its breadth into two, [with so many] degrees to each side, is the line of the zodiac circle itself [the ecliptic], whose path [runs through it].

[This central line] has no breadth at all, like the other circles of the sphere; beneath this aforementioned line the sun always travels [מהלך השמש], and — to the ancients — [the sun] never departs from it, all the days of the world, for which reason it is called "the course" [מסלול]. This line is also called "the line [קו…]"; and in the Latin tongue [it is called] "linea ecliptica" [Latin: linea ecliptica, "the ecliptic line"], because eclipses [קדרות] befall neither the sun nor the moon except when they are beneath this line — as will be explained further. And now hear the definitive rule and law of the belts and the circle of the zodiac and its working.

Know that the scholars of stars and signs divided the whole length around the belt of the zodiac into twelve large parts [לי"ב חלקים גדולים], each part comprising exactly thirty degrees [שלשים מעלות] — such [that] the sum of the degrees of each [of the twelve] amounts to [three hundred and sixty] degrees. These large parts they called "signs" [מזלות], and to each sign they gave a name according to the figure depicted there, [each] in its place. Their names are: (Aries [טלה], Taurus [שור], Gemini [תאומים], Cancer [סרטן], Leo [אריה], Virgo [בתולה], Libra [מאזנים], Scorpio [עקרב], Sagittarius [קשת], Capricorn [גדי], Aquarius [דלי], Pisces [דגים]); and a mnemonic for them is: טש"ת סא"ב מע"ק גד"ד [the initial letters of the twelve signs; first groups reconstructed, מע"ק גד"ד legible].

And you should know that these figures mentioned are [merely conventional]: the sages did not fix them as shapes in the [heavens] themselves, but only as it arose in the mind of the ancients

[§107, continued — right column:] …to depict a shape for each and every sign, as [the students would see]; the ancients [did this] in order to [teach] them and to instruct the students, [saying]: this star [belongs] to this [sign], and this star to that [sign] — so as to mark and depict thereby the figures, [and to say,] "such-and-such a star is on the head of Aries [ראש מזל טלה], such-and-such a star hangs on its horn, this on its nose, this on its back," and so on; and so they did for all the figures — Taurus, Gemini, and the rest. Had it arisen in the mind of the ancients [otherwise], they would have named [them otherwise], as you [may] see in the

nature of the compound stars of which we spoke above, in the First Section, in §56 [נ"ו?]: for the astronomers depicted [certain stars] as the figure of a Bear [דוב], whereas the common folk depict [them] as a Wagon [עגלה]. And so with the belts of the zodiac [and the rest], whose total is [140? ק"ם] [?] figures, [which] they now [use] to remember [the stars] by [?].

As for why the ancients chose to depict each of the twelve [signs] of the sphere in the figures of living creatures [בצורות בעלי חיים], and not [otherwise] — this is not without reason. Some say [יש אומרים] that each figure and sign indicates a specific action and property known to [each]: as Leo [אריה] and [Aries] indicate strength [גבורה], Virgo [בתולה] [indicates] satiety [שובע, i.e. harvest], Libra [מאזנים] justice [משפט], and so on; [Gemini indicates?] the heavens, and so the rest of the figures. For it is already known that every [herb below has a power set over it]; [the constellations were] given, from the days of creation, power and benefit for the array [of nature] — as our Sages of blessed memory hinted in [tractate] Berachos, chapter 10 [?], saying, "There is no herb below that does not have a constellation [mazal] in the firmament that strikes it and says to it, 'Grow'" [cf. Bereishis Rabbah 10:6] — and [likewise] "who knows the ordinances of the heavens" (cf. Iyov 38:33), and so on. So too, [in Moed Katan,] chapter "Ve-elu megalchin" [ואלו מגלחין], [it is stated] according to their testimony of blessed memory [?] — concerning [the influence] and the decree of the stars.

(108§) סימן ק"ח — For what reason the astronomers gave the zodiac circle the aforementioned breadth

Know that the scholars of the stars examined and refined [their] observations and said that the sun, in its sphere, is always [traveling] as [is] its way beneath the belt of the sign — that is, beneath the line that halves the breadth of the belt, which is the line of eclipses [קו הקדרות, the ecliptic]. In their view, [the sun] never moves from it, all the days of the world. The other planets [כוכבי לכת], however, are always revolving, each one close alongside this line, and they do not distance themselves from it by any [more than a fixed amount]: according to the earlier [astronomers], at most [a certain number of] degrees, and according to the later ones, who were more precise [?] — [and by observation, for] each star of the [planets] — the measure of the nearness and distance from this line will be explained to you further on, in the Eighth [Section], §241 [רמ"א, recte רמ"ח?]. With the help of God. And I, the writer, heard directly from [Johannes Kepler] ([Latin] Iohannes Keplerum) [יסאניס קפפלירום = Johannes Kepler] that the greatest distance of the planets [?] from the line [of the ecliptic] ... the greatest distance of the [planet] from it [is] toward the north and [south] three degrees [מעלות ג'?] [?]

... toward the south three degrees [?] ... the star of Mars [מאדים], its greatest distance northward, three degrees [ג' מעלות] [?] ... northward alone, three and a half degrees [ג' מעלות ומחצה] [?], and so on; there is some difference [in these values] between [the planets]. ... [The planets'] course is always beneath the line of eclipses [the ecliptic] ... [Mars?] distances itself from it more [?], in a circle toward the north, and likewise toward the [south]... [Region against the gutter, degraded; several planetary latitude values uncertain — see QA.]

[a certain number of] degrees in all, extending three degrees [ג' מעלות] [?] to each side.

(109§) סימן ק"ט — That the ancients agreed, by reasoning and sound cause, to set the sign Aries as the head of the zodiac signs

Although the sphericity of the sphere admits in it no [beginning], and no [fixed] endpoint by first intuition — so that [it would be] fitting [to begin anywhere] — when the sages wished to establish and be precise about the course of the sphere of the signs, they were obliged to choose for themselves a known point, upon which to agree, to set as the head from which to begin the reckoning. And since every part of the sphere of the signs is equal [to every other], [they had grounds to choose]. Yet they chose [a particular point] on account of several natural properties that exist [there] and that make it fitting to set as head and beginning: [namely, one] of [four?] points on the sphere, and they are — the head of the sign Aries [ראש מזל טלה] and [the points] paired opposite it [?], where day and night are equal in all climes [the equinox]; and it happens to them [?] at the time [of the equinox], balanced between heat and cold, and [likewise] the two points [of the solstices], the head of Cancer and the head of Capricorn [ראש סרטן וראש גדי] — [Cancer,] where, upon the sun's entering the head of Cancer, the summer reaches its fullness for us and the heat is at its strongest; and [Capricorn,] where, upon the sun's entering the head of Capricorn, the summer [i.e. daylight] is at its shortest for us and the cold reaches its completion, as all this was explained above, in the Second [?] Section. So you have four points, which have a status more distinguished than the other parts of the circle of the zodiac.

Indeed, [know] further that we [chose Aries] because, at the entry of the sun into [Aries], the time of the conjunction [?] [falls] between the lengthening of the days and their shortening [i.e. the equinox]; and this is so [?] — for most inhabitants of the world, and for those who dwell in the north, the [equinox] is the [balance] between cold and [heat], [always] equal, [the] mid-point between the two climes.

In this regard, [the sign] and [the points] paired [with it] are equal. The astronomers therefore [chose the head of Aries]: for when [the sun] enters it, [it is] the moment [that] finishes the [?] — [the change] between cold and [warmth] — [the season] neither very cold nor [?]. At [the sun's rising into Aries], the living creatures and the plants [flourish], for the heaven [grants ease] and moisture; the warmth exceeds [the cold], and the heat over the cold; the [vital fluid, the blood,] begins to increase in the body of living creatures, [both] man [and beast]; [the plants] are saved and blossom — every herb and [growth] sprouts from the ground. The reverse of all this [comes] from the time of the sun's entering the sign [of Capricorn, in the] signs [of winter], at which begins the onset of the winter days, whose season is cold and dry and brings [everything] to decay, in every matter [that concerns] the sustenance of man [?]. Therefore they judged the sign Aries [to have] the status of the firstborn [משפט הבכורה], being the head and beginning of all the twelve [signs], each of thirty [?] degrees [כל י"ב מעלות; "the twelve," each 30°].

(§110) סימן ק"י — The figures on the sphere of the zodiac are reckoned in two ways [aspects]

Know that the figures on the [belt] of the sphere of the zodiac have two distinct considerations [שתי בחינות], according to what was mentioned at length in its place, [where] the astronomers agreed [to set?] the sign Aries as the head of the signs, which is received [as the point?] from which they open [i.e. begin] the line of the signs and the line [of the ecliptic?]…

שער ה — The Fifth Gate (Sha'ar 5), continued

*Running header on every page: **שער ה** (Sha'ar 5). The prose is set in two columns per page (read right column first, then left). The 1743 square type is heavily worn on these leaves; genuinely illegible words and numerals are flagged [?].*

[§110, conclusion — from PDF p. 77]

and so they divided the sphere of the signs into twelve parts, and each part is called a *mazal* (a sign). By this reckoning nothing changes: no sign ever departs from its allotted domain. Upon the sphere [of the constellations], however, there is a slow motion [precession], so that over the long course of time the figures shift away from the points at which they once stood, [drifting] from the equinoctial point [?]. The twelve signs, by contrast, are bound and joined fast to the equinoctial point [נקודת המשוה], fixed so that [that point] never separates and

never [departs] — from the beginning of Aries [ראש טלה]; and the figures [of the constellations] remain bound [to the parchment globe], and by [precession the equinox] never breaks off entirely [?].

These are the fixed constellations, which are never equal to one another. [It follows] from the globes that are fashioned [by hand, drawn upon parchment and metal] [?]. Know that this matter is not yet fully known to me with precision [author's aside — reading uncertain], according to the globes I have drawn [?]....I have heard it in the name of my teachers [מפי] [?]... The whole sphere of Aries, corresponding to its figure [כצורה]... [text degraded]... and the seasons [תקופות] and the days [remain] in their [fixed] places forever [?].

סימן קיא (§111)

The constellations bearing figures in the eighth sphere are not equal to one another in their measure — neither in their length nor in their breadth.

The stars and the ancient constellations, which [the ancients] named — each according to the figure they agreed upon for it [?] — [the ancients] did not divide the constellations into equal portions, neither in their length nor [in their breadth]; for there are constellations that are compressed [יקדר] by their nature, such as Cancer, because its place [?]... and [some are] short, spanning [few] degrees of the twelve [signs]... while others [are long], spanning [more] of the twelve... spreading over into the portion of the sign before it and into the sign [after it].

Now know that not all the figures of the constellations are equal in their [extent]; rather, one of them inclines toward the north [like...] and one inclines toward the south, like Scorpio — all this [being depicted] as figures upon the globe that resembles the sphere of the heavens. And as to why [the ancients] did not divide them into equal portions: I do not know a sufficient reason [?]; only what has been mentioned, [namely] a tradition [handed down] to you [?] — "such a constellation abides thus, and opposite it such a constellation holds [thus]" [?] — and by these [figures] they gaze upon [the heavens] [reading uncertain].

סימן קיב (§112)

That all the stars of the firmament are divided among the twelve signs.

Since the circle of the signs — whose parts are 360 degrees [?] — [they reckon the stars] to it, [this gives] a breadth of 12 [degrees] [?]...

and they also divided it into twelve parts and called each part [a sign], so that the measure of each sign in length is thirty degrees, and [in breadth] some sixteen degrees [?]. [Ptolemy?] makes known that they wrote down for one consideration [?]: for its length 180 degrees and for its breadth thirty degrees. After they had divided the circle of the signs into twelve parts, the lines that [run] between each sign and the next are drawn from both sides — [north] and south — to the two poles of the circle [of the signs]. In this manner no star in the eighth firmament will [fall outside] one of the twelve signs; and it follows, by this consideration, that each sign [runs] from pole to pole 180 degrees, while its breadth, corresponding to a length of thirty degrees — thirty degrees [?] — [narrows], for the widths of those parts diminish and taper from both sides after their [maximum], until, on reaching the two poles from this side and that, they return to the [pole-]point and have no breadth at all.

סימן קיג (§113)

That the divisions of the sphere of the signs are reckoned according to seven considerations.

In sum: from the things we have mentioned it will be clear to you that the divisions of the sphere [of the signs] are reckoned according to seven considerations. **(א)** The degrees of the equator [קו המשוה], and likewise the degrees of the ecliptic [קו הלקות] or otherwise: the division of the 360 degrees of the sphere into twelve parts, which are the twelve signs, the length of each sign being thirty degrees. **(ב)** [The breadth...] [?]. **(ג)** [...] the twelve signs [?]. **(ד)** A breadth of thirty degrees [?]. **(ה)** Consider the lengths of the signs [?]... **(ו)** [consideration illegible — [?]].

And there is furthermore a **seventh consideration**, added to the [foregoing] considerations — a new consideration, which I received from the scholar Kepler [קעפליר; Johannes Kepler]: [its content — reading largely degraded] — [concerning] the whole depth of the globe [?], each part filling twelve [?]... the lengths and the breadths of each [?]. [More than two words of this seventh consideration are illegible; see QA.]

סימן קיד (§114)

[Printed heading abbreviated; reads "סי׳ קיד"]

The six signs [that stand above the horizon]... are not found [equal, neither to the east] nor to the west, except for those who dwell beneath the equator [קו השוה].

[Body largely on the left column, p. 78:]...[for those under the equator] the six signs [above the horizon behave as described]; but for those [dwelling to the north or south this differs] [?]. [Several clauses degraded — [?].]

סימן קטו (§115)

[Printed heading "סי׳ קטו"]

[That every sign draws out its rising over a set span of time — the division of the rising-time into hours and minutes.] *(heading partly degraded)*

From the moment each sign begins [to rise until it has risen] wholly [?]... by reason of the [governing] principle [?]... hours; and this matter [is treated by] Heindrik [?] [חיננדריך — name uncertain, [?]] in particular [?]... that [the sphere] carries the whole [heaven] round from [pole] to [pole] within [some 34?] hours [numeral [?]], so that in its course it reaches every [meridian/point] [?]. [This section is heavily worn; multiple clauses [?].]

סימן קטז (§116)

That every day six signs rise, and likewise in its night — whether the day or the night be long or short.

In all the climates [אקלימים] [six signs rise], and likewise six signs [set] during the night; in every climate, no fewer and no more [than six]. If the day be [short], then the night is long [?]... and so six signs rise in the span of six [hours] [?]. ...thirty degrees fall to each hour, and each hour amounts to [16?] degrees [numeral [?]]... before [the sun completes] its daily revolution, it finishes its circuit, as I explained in siman 106 [סי׳ ק"ו]. All this is for those who dwell beneath the equator, in the days of the Nisan and Tishrei equinoxes [תקופת ניסן ותשרי], and not so in the rest of the days of the year, because [of the changing position]... six signs rise in the span of [six hours] whether the day be long or short, as will be explained... [At the summer solstice, תקופת תמוז,] they rise in the span of six [?]... reckon each sign at two hours and two [minutes] [?]... according to its position [some] rise [in more or fewer hours]... [one] sign [in] an hour and a third [שעה ושליש]... and the matter is reversed [elsewhere]. Beyond that there are [precedence and lag] — many differences and variations [?]: one [sign rises faster] than its fellow, even for some of those dwelling [near the equator]; [some] rise in a single hour, and for some of them [Pisces rises] before Aries, [and] Aries before Pisces [?], as [depicted in a diagram/figure] of this kind in this Gate [?].

סימן קיז (§117)

Explanation of the ascensions of the signs [מצעדי המזלות] and their direct rising [וישר]: that there is a sign which rises slowly (at length) and a sign which rises quickly (in short span).

The divisions of the signs [as they cross] the horizon — the astronomers call them the *ascensions* of the signs [מצעדי המזלות] [and the "line of right" / right ascension], of which we shall speak [?]. Let it be known to the reader that the division of time into hours and minutes [corresponds to] what the sphere of right [גלגל הישר — the celestial equator] revolves over the horizon, or over the meridian [קו חצי היום]... [that is,] the daily rotation of the sphere, as was explained above in the fourth Gate [שער הרביעי] — in such a way that you may know the time of the rising of the signs, namely, their ascensions.

These too are reckoned by the revolution of the parts of the sphere of right [equator]. A star, for those dwelling [beneath the equator], [rises] at the measure and rate of thirty [degrees] [?]... in one full hour it hastens and does not tarry in its rising, [nor] in its setting.

And now know that we must be exact concerning the signs [?]: for although they too are portions that revolve perpetually [with the sphere], [and] they hasten and do not tarry in their revolution, time after time — [nevertheless] from the equator [?]... [where] equal portions [of the ecliptic cross the horizon as] unequal portions [of the equator] at times, [at times] more than this and at times less. The matter, and its reason — hear it: Know that were the sphere of right [equator] standing directly [above], from the [meridian] — as [a straight line] [?] — from pole to pole... [it would rise evenly]; but [because the ecliptic is oblique,] the signs precede and lag, one relative to another, upon the poles and axis of the circle of the signs [ecliptic], which are inclined from the poles of the world — as stated above in siman 36 [סי׳ ל"ו] — because [the ecliptic] is [inclined] from the sphere of right [equator] and does not stand directly opposite it.

[the signs] Gemini and Cancer, and likewise Sagittarius and Capricorn — since their standing [?]... [Aries and Pisces, near the equinox,] stand more evenly opposite the equator than all the other signs [?]; [for these] they call it "direct rising" [עלייה ישרה], yet even so their rising is a [slow] rising [?] — [only] slightly [faster] [?], because the circle of the equator stands [obliquely to] the globe. As for Sagittarius [and the others]... the four signs mentioned, [28?] [numeral [?]]... [standing] opposite the equator [?]... [at] the lower part of the globe, it follows from this that... its standing opposite [it] and the measure of its arc holds more

[?]... [the ascension of] Sagittarius equals the length of the sign lying opposite it, measured from the arc of the [equator].

סימן קיח (§118)

Explanation that in [four] places the divisions of the signs vary [in relation to] the divisions of the equator [קו הישר].

Know that for those who dwell beneath the equator [קו הישר], the signs are made equal, day by day, with the divisions of the equator. [At four places] the sphere of the signs [rises] in its equal place, day and night: these are the beginnings [ראשי] of the signs Aries and Libra [the equinoctial points], and the [two] places where the sun stands [at its turning], the beginnings of the signs Cancer and Capricorn [the solstitial points]. And what [one place] falls short, [the other] fills [?].

[at the] returns of the signs Aries and [Libra?]... [these] signs, and their rising [takes] less than two hours [?]... and [Aries?] and Sagittarius are made equal; there [one] precedes [?]... more than [42?] hours [numeral [?]], and likewise the law is [as for...] [?]; [whereas] in Cancer and Capricorn the rising of the equator precedes [?]... and [Libra?] is made equal, [where] the [equator] lags [?].

סימן קיט (§119)

The order of precedence and lag, according to the arrangement of the four quadrants of the sphere [ארבע רביעי הגלגל].

In the first quadrant, Aries [precedes]... Taurus lags [?]. In the second quadrant, Cancer lags [?]... In the third quadrant, [Libra]... [?]... In the fourth quadrant, Capricorn lags [with] Aquarius [?]. And just as [is] the rule in their rising, so [is] the rule in their [setting]: [what] lags in its rising [?] precedes... [what] lags in [setting] [?]. And [the reverse] holds in their rising upon the horizon [?], and [the reverse] in their setting upon [it] [?].

סימן ק"ך — The Ascension Table (§120)

[Printed heading appears abbreviated as "סי׳ק"; by the running sequence §111–§119 it is §120. Numbering flagged in QA.]

A small table [showing] how many degrees and minutes — [and how many] hours and minutes — the rising of each sign [takes], whether direct [rising] or [oblique].

I saw fit to set before you a small table, in which you will find the rising of [each sign]... and its [degrees and minutes] — how many degrees it precedes or [lags]... [reckoning at 16?] degrees to the hour [?]... and take the difference for yourself; from it you may understand the rest of the [hidden values]... [for one sign] the rising from the equator [קו הישר] is 57 [נ"ז] degrees and 33 [ל"ג]... [?]... [some] 21 [כ"א] minutes [numerals partly legible in the prose but not committed here — see the table note], and so the rest.

Table (§120)

The table reads **right-to-left** in the source: the rightmost data column is **Aries (ראש טלה)** and the columns proceed to **Pisces (ראש דגים)** at the left. A right-hand label column gives the row names. In the markdown below the row-label is placed first (left) for rendering; the twelve sign columns follow in source order (Aries → Pisces).

The five rows are: **מעלות** (degrees of ascension), **דקין** (minutes), a ✻ separator row, **שעות** (hours of rising), **דקין** (minutes).

The small-gematria interior cells do not resolve cell-by-cell even at the highest magnification; every interior value is therefore left `[numeral: ?]` rather than guessed. The grid structure, the twelve sign-name headers, the row-labels, and the ✻ separator row are committed.

(row)	ראש טלה [Aries]	ראש שור [Taurus]	ראש תאומים [Geminii]	ראש סרטן [Cancer]	ראש ארי ה [Leo]	ראש בתול ה [Virgo]	ראש מאזנים [Libra]	ראש עקרב [Scorpio]	ראש קשת [Sagittarius]	ראש גדי [Capricorn]	ראש דלי [Aquarius]	ראש דגים [Pisces]
מעלות (degrees)	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
דקין (minutes)	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
✻	✻	✻	✻	✻	✻	✻	✻	✻	✻	✻	✻	✻

(row)	ראש טלה [Aries]	ראש שור [Taurus]	ראש תאומים [Gemini]	ראש סרטן [Cancer]	ראש אריה [Leo]	ראש בתולה [Virgo]	ראש מאזנים [Libra]	ראש עקרב [Scorpio]	ראש קשת [Sagittarius]	ראש גדי [Capricorn]	ראש דלי [Aquarius]	ראש דגים [Pisces]
שעות (hours)	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
דקיקל (minutes)	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]

שער ה — Fifth Section (continued)

121§ — סימן קכ"א. The laws of precedence and lag in the ascensions of the signs, for those dwelling beneath the equator [ליושבי תחת המשוה; printed המעות, a compositor garble]

Know that everything we said above concerning the differences and distinctions found in the ascensions [מצעדי] of the signs applies specifically to those who dwell upon the equatorial line [קו הישר / the equator]. As for those who dwell [away from it], you should know this: the precedence and lag relative to the equator is only slight — the difference amounts to no more than about five degrees, so that the sign which is the most delayed of all [differs only a little]; the difference between them [is small]. But for the stars and signs [situated far] from the equator, the difference will be great and considerable, roughly in proportion [to the distance]; and it all depends on the amount of inclination [נטייה] from the equator: the farther they are from the equatorial line, the greater [the difference], as will be explained further on.

And know that as for the risings and settings [and ascensions] for us [in these latitudes]: the [six signs mnemonically marked] (ט"ט ת נד"ד [?] — the printed mnemonic is garbled; it denotes one half-group of six signs) rise quickly upon

[the horizon], for all of them are swift in their rising and slow in their setting; whereas the [six signs marked] (סמ"כ מע"ק [?] — the other half-group, printed mnemonic garbled) [rise slowly], for all of them are slow in their rising and slow [in their setting]. And know that the stars outside the equator do not [rise and set] in the manner of the straight sphere [גלגל הישר] except in two places only [the two equinoctial points].

122§ — סימן קכ"ב. A table [showing] how much the rising of the signs and their setting amount to, for us the inhabitants of the city of Prague

For the completeness of the work, I have thought fit to set before you a small table, constructed according to the elevation of our pole here in Prague, from which you may learn the rising and the setting of every sign — in degrees and minutes — how many parts each of them rises. Thus, according to the reckoning of the complete motions [תנועות שלמים] of the degrees upon the straight sphere [גלגל הישר], [you may know] the risings and settings of each sign.

The meaning of this table is precisely the double [כפל] of the adjacent table above [i.e., the right-sphere ascensions]. For example, the sign Aries — as its column shows — its entire rising in time, reckoned from the equator [קו הישר], amounts to [?] degrees [?] minutes [reading uncertain, ~13°31′?]; and they rise [?] [53?] minutes [?]. All of this is written according to the elevation of the pole here in Prague, whose pole-elevation is [כ'/נ' — printed value uncertain] degrees [?] and [?] minutes (Prague's latitude ≈ 50°). And from it one may verify, by the science of the sphere, [the corresponding values] for the [other] signs — for each and every place, according to the elevation of its pole.

עליית המזלות — Rising of the Signs [Table, for Prague]

Table reads right-to-left in the source (rightmost column = Aries). Twelve sign-columns plus a left-hand row-label column; four data rows.

Row label	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
מעלות (degrees) [?]	[num	[numera	[numeral:	[numeral:	[num	[numeral: ?	[numer	[numeral: ?	[numer	[numeral: ?	[numeral:	[numeral:

Row label	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
	eral: ?]	l: ?]	?]	?]	eral: ?]	]	al: ?]	]	al: ?]	]	?]	?]
דקים (minutes) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
שעות (hours) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	✻ [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
דקים (minutes) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]

ירידת המזלות — Setting of the Signs [Table, for Prague]

Same structure as the rising table (twelve sign-columns, four rows), reading right-to-left in the source.

Row label	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
מעלות (degrees) [?]	[nu	[num	[numeral:	[nume	[nu	[numer	[numer	[numer	[numer	[numer	[nume	[nume

Row label	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
	meral: ?]	eral: ?]	?]	ral: ?]	meral: ?]	al: ?]	al: ?]	al: ?]	al: ?]	al: ?]	ral: ?]	ral: ?]
דקים (minutes) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
שעות (hours) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]
דקים (minutes) [?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]	[numeral: ?]

A small note [הערה קטנה]. Know that everything we have said above about the rising of the signs and their ascensions — what rises [in one place] — rises differently elsewhere, [each place] according to its inhabitants' clime. Therefore know that for all who dwell outside the seven climes [שבעת האקלימים], the opposite is found regarding the settings and risings of the signs. And it is exceedingly wondrous that there are countries where the circle of the signs [stands upright] to the horizon [?]... so that each day, in each of the twelve signs [is divided]; then signs rise for them above the horizon and set opposite them, as [we explained]. There are also countries where the signs [rise in reverse]: Taurus [rises] before Aries, and Aries before Pisces [?]; countries where signs [become visible] and remain above their horizon... [others that] set from them all the days

of the world, while the other signs never rise for them at all. Choose for yourself these natural arrangements, in their order [?].

123§ — סימן קכ"ג. Concerning some people, for whom each day the circle of the signs [lies aligned] to the horizon, so that each of the twelve signs appears to them with half of it above the horizon and half of it below the horizon

Those who dwell at the equator [מצד המשוה], [with respect only to] the northern pole [קוטב הצפוני]... [?] minutes, so that they are distant [from it by] about twenty[-odd] degrees [?] minutes, as [is now the case at] the start of the countries of [?]. Likewise the inhabitants of the far end of the countries of Sweden [שוידי"ן] and Norway [כורויג"ן = Norwegen], for whom... since all of them dwell beneath the northern [pole] circle, the circle always revolves about the point of their zenith, from above [?]... forever. And since it has already been explained above [?]... the northern circle [?] only [?].

124§ — סימן קכ"ד. When the axis is inclined [so the pole stands at the zenith]: for the heads of people dwelling beneath the northern [pole] circle — as [at] the equator [?] — [six] signs of the zodiac rise and six set from it at one and the same moment [בשעה אחת]

Know that when [the pole is at their zenith]... from the circle of their vision [ראייתם] they do not [reach] to the horizon; rather the horizon cuts [the sphere] as any two great circles [that bisect each other], [and] so all [the signs].....nine signs opposite them, which in the [southern] places are near, as [described] below; [beneath] the northern [circle], since every sign [is included]... more than half of them always [remain above the horizon], only [some] set from them; and by their inclination all of them descend below to them [below] the horizon, while the other signs rise. In all these matters, things appear [tangibly] which cannot be depicted upon a [flat] surface.

125§ — סימן קכ"ה. We find three signs that remain always above the horizon, and three [always] below it, and six that rise and set alternately [מתחלפים]

The people [dwelling where the pole reaches] toward [?]... [oblique] degrees, as [we said], 66[?] degrees and no more — only twenty[-odd] degrees [?] — as mentioned above [כמו שהוא נזכר למעלה]: for those people there are three signs, of the fixed [northern] signs [set] to the sides — namely Gemini [and its group?]... and [likewise?] Capricorn, and the two signs opposite them, which... are hidden from them beneath the horizon [always]. There are signs which both rise and also set for them — marvelous and wondrous — for [Taurus] rises for them in the reverse of the [usual] order and manner: for there Taurus rises first [and Aries after], and they set in their order, Pisces first; and the setting of the visible [southern] signs [is likewise reversed], [so that] they rise in their order and set [in reverse], [Libra] and after it Virgo. The reason [that] Gemini, Cancer, Leo [and Virgo], like the rest, [rise thus] is because of [their nearness] and their inclination toward [one side]; therefore, by reason of the change in the inclination of the [horizon] line, the signs [oblique] to them upon their horizon [rise thus]. The [southern] stars [nearer] to them, namely Sagittarius, Capricorn [?]... [in the] south, are found more sunken and distant [from view]; and [others] are hidden from them forever.

126§ — סי' קכ"ו. For some, four signs remain above their horizon and four [below]; and for some, six [remain] above the horizon and six always below it

You should know that in some of these places — for those distant from the equator [by] 70 degrees — [the effect] reaches up to four signs, which are [Gemini], Cancer, Leo [and the rest] upon their horizon: they never set from it; and the four signs opposite them, which are Scorpio [?], Capricorn, Aquarius, are hidden from them beneath the horizon always; and [Sagittarius?]... Six signs rise for them, namely (ט"ש ת"ס א"ב [printed מט"ת כח"ב, garbled] = Aries, Taurus, Gemini, Cancer, Leo, Virgo), like the rest, upon the horizon; and six signs, namely (מ"ע ק"ג ד"ד [printed מע"ק נד"ד, garbled] = Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces), are hidden always beneath the horizon. All of this you can see [by] the science of the sphere; this matter will be made clear to you, as [with] the pole, [as explained] nearby, in §§ קמ"ד and קמ"ו [144 and 146?; reference uncertain].

127§ — סי' קכ"ז. Reckoning the rising of the signs upon the horizon: some of them an evening rising [עלייה ערבית / acronychal], and some of them a morning rising [עלייה בוקרית / cosmical]

Know that for every sign, and likewise for every star, there is found an [inclination] with respect to rising, [in] two aspects: the one is called an "evening rising" and the other is called a "morning rising." The evening rising is when the star or sign rises... at any horizon... just after the sun has already set [in] the west; this rising is called an "evening rising," and for it one needs no demonstrative reckoning whatever, for the matters [are visible] to the eyes just as [they are] in the world. The morning rising is when a sign or a single star [rises] together with [i.e., just before] the sun [comes up] upon the horizon; and this the eye cannot perceive properly, because of [the sun's light] — [it can be grasped] only by calculation and reasoning; therefore this rising is grasped [only] intellectually. Therefore know the reckoning of the rising of the twelve signs [through the year]: Aries in Nisan, Taurus in Iyyar [Gemini in Sivan, and so on].

128§ — סי' קכ"ח. On the rising of the twelve signs in [the course of] the year — and this is not by reason of the revolution of the sphere of the signs [but of the sun's own annual motion]

From the New Moon [ר"ח] of Nisan... [at] the true [tekufah], for on that day the head of the sign [Aries] rises upon the horizon first; and at the New Moon of Iyyar the head of the sign [Taurus] rises upon the horizon first; and so at the New Moon of Sivan the head of Gemini rises first, and at the New Moon of Tammuz Cancer [rises] first. And so are the rules of the rising of the signs at every New Moon until the end of the year — for at the New Moon of each month a [particular] sign rises, and at the next [New Moon] the head of [the following] sign [rises] upon the horizon [?] as at first; and thus the matter recurs perpetually.

And there is [reason] to inform you — lest, on account of this, you should think that the sphere of the signs circles the globe of the world once each year: the matter is not so. [The sun] by its own motion, according to the reckoning and precision of all the later [scholars], does not circle the globe of the world by itself except in about [?] thousand years [precessional cycle], as will be explained. The cause that produces the phenomenon of a [different] sign [rising] above the

horizon each month is [the sun's own] motion — by its proper motion toward the east, [nearly one degree] each day — as will be explained shortly. For had the sun stood still in one place, then when Aries had risen upon the horizon first by [the diurnal] motion, on the morrow [the same point] would rise with the head of that sign and would not change its rising from its place. But because [each day the sun shifts], when Aries rises upon the horizon the sun is no longer found [there], for it has already moved by its own motion about [thirty degrees over the month] eastward, [now] with the head of Taurus; therefore [Aries] does not rise [with the sun] upon the horizon... [The sphere of the signs] is carried by the diurnal sphere [גלגל היומית]... degrees, [at] the point which is the end of Aries and the head of Taurus. And so at the New Moon of Sivan the sun rises upon the horizon with [the head of Gemini], and so its rule [holds] until the end of the year, and so it recurs perpetually. Here, then, is the reason that Taurus rises upon the horizon [in Iyyar] — [it is by] the completion of the sun's circuit, not [by] the [proper] actions [of the zodiac sphere].

Or [the matter] may be reckoned another way: when at the New Moon of Nisan the sun [rises] with the first degree of Aries upon the horizon, then on the morrow, on the second day, when the head of Aries rises upon the horizon, the sun is not found there with the head of the sign, for it has already [moved] by its own motion about one degree; therefore [the point] rises on the second [day] upon the horizon with the second degree of Aries, and on the third [day] it rises upon the horizon with the third degree, [and so is] its rule from day to day until the completion of thirty days, when [the head of] Taurus [rises], as above.

And you should know that all we have said is approximate, for the sun does not circle a full degree each day, [nor] thirty full degrees in thirty days, because [in a year] which is 365 days and a quarter it circles 365 degrees, so that the reckoning does not reach a full degree each day, but only about [?] minutes [?] seconds [~59′ per day], as will be explained in the Fourth Section [שער הרביעי]. And in this there are yet further matters, in that the [stellar] reckoning is not exact [i.e., not in precise round terms], as will be explained.

129§ — סימן קכ"ט. The rising-degrees of the aforementioned signs [do not come out] exactly [the same] in every year, and are not equal for all the inhabitants of the world [יושבי חלד]

[The matter rests upon several] causes... [and depends on] the horizon [every 33 days?]... what we said, that at the New Moon of Nisan... the true [reckoning], the head [of Aries] rises... first. But know that there is no [single fixed] reckoning

[that holds] in every year [?], for the sun does not [aim precisely] at the head of Aries at the beginning of the day, at the moment of its rising upon the horizon; this occurs only [when] the sun rises at the beginning of the night, or... between night [and day], sometimes by several hours [earlier or] later. And also know, O inhabitants of the world, that [this requires] the correct [value] to be known for [the latitude of] the country, for this reckoning was founded upon [certain] inhabitants... in the morning; for at the time it is day [for one place] it is night [for another], and for the inhabitants of the far west [it differs from] the inhabitants of the far east... we anticipate the head of Aries and the center of the sun by about one part [degree]... [and] the rising of the sign begins [there]. [There will be] a slight difference... [and] the [sun's setting] anticipates [for the northern dwellers over the southern dwellers], as will be explained below in §132 [קל"ב].

130§ — סימן ק"ל. On the period of the revolution of the sphere of the signs [the great precessional cycle]

Concerning [the period of] the revolution of the sphere of the signs there is confusion [קלקול], disputes and differing opinions among the sages [and] the ancients, and there is a great and considerable difference among them — [some holding] its revolution [to be longer than that of any other]. The reason for this is [that even] there [among them] there was disagreement... and from two kinds of reckoning... from [?] [49?] degrees... [?] [27?]... and the Yalkut [ילקוט] brings [?]... the ancients [reckon] so many [?] days in order to [?]; and I have found it written that the sages incline toward [the ancients / קדמוניות?] and from much [?]...

שער ה — Section Five (continued)

130§ — סימן ק"ל (conclusion): the great precessional cycle (continued from the preceding page)

this is what I have written concerning it, in view of the smallness and deficiency of its motion — a motion so slight that on these grounds some have judged, by their observations (even [?]), that this sphere has no motion of its own at all. Yet the eminent sages Euclid [אקלידו"ס — Euclid?], [?], and [?] did detect in it a motion of some kind, though they could not, by their own account, assign it a measure — a measure for the span of its revolution — until Ptolemy arose. Ptolemy, foremost of those who spoke with precision, likewise detected a motion in it; but it did not suffice him to determine exactly how great its motion is, so he made a rough, approximate estimate — though he himself knew that his estimate was not an exact and rigorous reckoning. He said that the motion of this sphere,

from west toward east, is one degree in about a hundred years. By this reckoning this sphere would not complete its revolution, from point to point, until the passing of 36,000 [שש ושלשים אלף שנה — confirmed under magnification] years.

After Ptolemy — about [?] years later, in the year [?] of the fifth millennium — the sage al-Battani [אלבתאני] the Arab also examined all the reckonings of the ancients, [combined?] his own work with Ptolemy's, and made good their shortcomings with [fresh] observations, [finding] that this sphere shifts one and a half degrees every hundred years. By this reckoning the sphere of the signs completes its revolution [in about — cycle figure damaged, [?]; 360° ÷ 1.5° × 100 = 24,000] … down to this day.

And Maimonides [הרמב"ם], of blessed memory, wrote in chapter 3 [reference [?]] that the revolution of the sphere of the signs is one degree every seventy years; by his reckoning this sphere completes its revolution in 25,200 years [כ"ה אלפים ומאתים = 25,200; 70 × 360 = 25,200].

And here is what I heard from the great and eminent sage of our own generation, [Tycho Brahe — טי"חא ברהא"סי], who said that he examined all the reckonings of the ancients with great and abundant precision, and found that the revolution of the sphere of the signs is [?] seconds every year — very nearly [the exact figure per year is not legible, [?]]. By this reckoning it amounts, per hundred years, to 82 [פ"ב — confirmed under magnification] minutes, which are one degree and 22 [כ"ב — confirmed under magnification] minutes; and by this reckoning this sphere completes a full revolution in about 25,[?] thousand years — very nearly — which is close to the reckoning of Maimonides, of blessed memory.

And now know: I heard from the words [?] of the sage Israeli [Isaac Israeli — הישראלי] a great and wondrous matter, [one] very hard [to grasp [?]], for in [his book?] he says that he [studied?] the books of the sages Ptolemy and al-Battani… and [others] examined [them] well… such as Abraham [?] who was in the city of Toledo [טוליט(ולה)]. And let us not say that the sphere of the signs never completes a full revolution like the other spheres for all the days of the world — rather [?]. It is only known that the sphere of the signs shifts eastward, and at another time westward; it is known that the sphere returns [?] to move… but not in its stars [?] westward — as he expounded at length there in his book, concluding that this is a sound reason and an exact configuration. [?] … and they said that this is the sphere of the signs with its stars, according to the opinion of [?].

And I, as I have expounded, concerning the motion held [?] by the sage [Möller — מוליר"ום, further review] of the sages who sit before the **Margrave (Markgraf)**

[דוכס — printed "Duke," but further review: the ruler of Brandenburg is the Margrave/Elector] of [Brandenburg — מכרא"נדיבור"ן]: he answered [them] that this whole motion is a slight one, called in their tongue [?] *trepidatio* [טריפידיאמ"ס — Latin: *trepidatio*, "trepidation"], that is, a motion of trembling and quaking [?]… and in his view it revolves in about **7,000** [confirmed under magnification] years; and there is no [further] motion or displacement [?] beyond the aforesaid, for the motion of the sphere of the signs is in every place [?] degrees [[?]], and it [holds fixed?] in its place…

[caveat, concluding §130 / §131:] …[Adjacent to this is] the opinion of some of the sages that the sphere of the signs at one time circles toward the east and at another time circles toward the west, so that it does not make a complete revolution like the other spheres for all the days of the world; for by [?] we do not find in their books… the motion of trembling and quaking… and after us [comes] the heavy motion of the sphere of the signs entirely — or it is necessary [?]… in the fullness of his words on this matter. Here we set it down: we do not know, and we cannot fully adjudicate this rule, for our intellect is too limited for it — and perhaps we have erred. In my opinion one should hold as [stated in] the Seventh Treatise [מאמר השביעי — i.e. Almagest, Book VII, on the fixed stars], [?], that this matter is exceedingly hard, and it is impossible for mortals to grasp it precisely except after many years.

131§ — סימן קל"א: that after many years the positions of all the host of heaven will change for us

[Heading, p. 85, left column:] "I will make known in it that after many years the positions of all the host of heaven will change for us."

Know that, by the course of the sphere of the signs — the degrees of the figured constellations, which are the fixed signs [?] set in the firmament for the eye to see — after many years there will come about, for all the inhabitants of the world, a great and manifold change and alteration in their appearance and their aspect together with [?] the sphere [of the signs] and the other spheres, corresponding to [?] the inhabitants of the world, since their [reference] point in the figured [firmament], which we mentioned above in §27 [סי' כ"ז], is for them at present above the horizon [אופק], whereas after many years it will be at a point below the horizon; and when all twelve signs are for us southern, they will then be for us [northern? — כלטלפויי [?]]…

Thus, for example: at the time when the point of the head of Cancer [ראש סרטן] is at their zenith, the point of the head of Capricorn [ראש גדי] will then be opposite

[at the nadir], and Aries [טלה], as a figure, will rise in the east [along with Libra? — כתשרי [?]] and Scales [Libra], with its accompaniment [?], and many other [changes] without number.

And to make it easier for the students to perceive all this with a little study and reflection, I offer an illustration and say: those whose place is at present situated under the circle of Cancer — which is 24 degrees from the equinoctial line [מקו יושר], in latitude, according to what I wrote above in §40 [סי' מ] — the northern pole [הציר הצפוני] is raised for them above the horizon by likewise 24 degrees; and the star [?] that we marked above in Section One [at the point in] the sphere of the signs answering to the upper pole-point — the point that I called, above in Section One, in §26 [סי' כ"ו], the "quasi-pole-point," since in their day it functions in every respect like the upper pole-point itself — therefore, by Ptolemy's reckoning, that the sphere of the signs revolves one degree every hundred years, know now that when the sphere of the signs turns as a whole upon its axes [כדוריו [?]], by this reckoning, after [some] thousands of years [?]...

the corresponding point marked in the sphere of the signs [will shift] from its place, so that, just as it was for them above the horizon by about 24 degrees, it will incline either toward the east — and this will be [above?] the horizon; and likewise it will incline toward the south and toward the west, [?] the horizon — and whereas at this present time the circle of Cancer, which is their zenith-star, will then likewise, by the sage's reckoning [?], after [some] thousands of years, at the marked point, part from its place and greatly change its place, so that, just as at this time it was above the horizon by 24 degrees, it will [then] be below the horizon by 24 degrees; and the southern point of the southern pole, which is now for them 24 degrees below the horizon, will be for them [then] 24 degrees above the horizon. And [for] the aforementioned sages [places], as it is now the circle of Cancer that is their zenith-star, then it will be the circle of Capricorn opposite their zenith, and Aries as a figure will rise in the east [with Libra? — כתשרי [?]] and the Scales, and many, many other [changes] beyond number — all which matters you can see, as it were with the eye's own sight, when you look at the pole [?] upon the two poles of the signs over the horizon and turn the sphere until the point we marked is 24 degrees below the horizon; and, together with [?], by Ptolemy's reckoning as mentioned, after 9,000 [ט' אלפים; [?]] years [it will happen thus], and by al-Battani's reckoning after [less time]...

[continues, p. 86, right column:] ...the positions [?] which were explained in the preceding [section]: by Ptolemy's reckoning after [?] years, and by al-Battani's

reckoning after 12,000 [י"ב אלפים; [?]] years, it will come to be [that the constellations reach the opposite horizon].

From all the aforementioned matters one may say that, according to what we mentioned above in Section One, §11 [שער הראשון סי' י"א], that every [?]... so too the heavy motion [carried] with the sphere of the signs [causes that], over the length of the ages, at the time of the winter solstice [תקופת טבת] [the sun] will draw near to us in the extreme of closeness, and the day will lengthen for us more than all the days of the year, and thus the heat will grow strong for us; while at the time of the summer solstice [תקופת תמוז] it will withdraw from us in the extreme of distance, and the day will shorten more than all the days of the year, and thus the cold will grow strong for us — [so that] cold and heat, summer and winter [will be reversed]. Nor does this contradict [our earlier account], since in the end these will [each] be fulfilled in their [proper] times and places; and at every time, likewise, you should know that, according to what we have made known above [it will be so].

With the help of the One who built the woman from the rib [cf. Bereishis 2:22], we have completed five Sections.

השער הששי — THE SIXTH SECTION (שער ו)

In it will be explained the declination of the sun from the equator [קו השוה], and the [variations] and wondrous variations found in this; and the lengthening and shortening of the days, and the wondrous variations found in this among the inhabitants of the world; also to know the measure of the days throughout all the days of the year, in every place and at every time; and the precedence of the times of daylight for the easterners over the westerners, and for the northerners over the southerners, and other great and wondrous matters, and more besides.

132§ — סימן קל"ב: on the sun's declination from the equator

We will speak in it of the sun's declination from the equator [קו השוה] — called in their language *declinatio* [דיקלי נצייאנו"ס — Latin: *declinatio*] — [and of how] the sun's [two?] circles [?] [cross the equator?] twice a year.

We have already explained above, in Section One, §24 [שער הראשון סי' כ"ד], that every [?]. [The sun,] in its daily circling [?] with the daily motion, makes each day one [circle]; the poles of the world [קוטבי העולם]... [it] stands ever at its [fixed] place [?], as with all the stars of the firmament, the fixed ones [סתמיים]. As we said, when it circles... the sphere of Cancer [?]... all the circles of the signs [?] cover [?] the equator from west to east, each [circle] once a day; and it comes

near [to the equator] for each day by one part [חלק], 22 [?]... and the [circles of the sun] rise, each in its place [?], where it was [?]... only that they are shorter [?], as the others [?] are farther from their point [?]; each is known [?], and it makes either a full circle or a night[-arc] — a single [circle for the] world [?]. As one may say [?], the sun's circles [are]... [drawn?] close to a full circle, [each] parting from the next slightly, [?] one for a second [circle]... circles [?] first among the days [?].

133§ — סימן קל"ג: that most of the sun's circles are paired with one another

[Heading, p. 86, left column:] "We will announce and make known in it that most of the sun's circles are shared, one with another — they are one with the other [in pairs]."

Know that, of the sun's circles, not every single one is a circle by itself for one day alone; rather, most of the heads of the circles are shared by two days [?]... in each and every degree upon [the equator?].

[continues, p. 87, right column:] ...upon two whole signs that share [the same] heads of the signs — these are: Gemini [with Cancer? — תאומים כסרטן [?]]; Taurus with Virgo [שור בבתולה]; Aries with [?]; [?] with Scorpio [עקרב]; Aquarius [with?]; Sagittarius with Capricorn [קשת בגדי] [pairing of the second member is garbled in several cases and flagged [?]]. That is: the circle which the sun makes [in its day] at the head of the signs [?]... For example, [the circle it makes] at the head of the sign Gemini [ראש מזל תאומים] — that very same circle it [also] makes [at] the head of the sign Leo [ראש מזל אריה], for the two are at equal distance [from the solstitial point], as with the rest. And there is no distinction between them at all, since both are [at the] same distance, only [that] the circle at the head of the signs [is] one, [and the corresponding one]... — this is the shared [pairing]; that is, one whole sign is paired with one [other] whole sign. These are they [as listed above], each one beside the other [?].

Now the circle which the sun makes on its day at the head of the point [?]... is the circle which the sun makes at the end of the sign of Cancer [סוף מזל סרטן], and there is no interval [ריוח] between them at all; and the circle which it makes at the head of the second degree of the sign [?]; the circle which it makes at the head of the 29th degree [מעלה כ"ט] of the sign Cancer [?], and so on, [each answering to another] until each pair of them [is] one beside the other in the matter [?]. So too with the other shared circles. All this "sharing" is only [approximate], as will be explained; only at the outset of the circles [is it exact], as will be shown.

And now know: [the fact] that the sun makes each year, by [this] reckoning, only [182 — קפ"ב] circles [?] — that is, that the sun returns and rides [?] on each and every circle [?] — and know also that, in your reckoning, whether [the sun be] at the head or at the end of the two shared parts of the sphere of the signs [?] together — so too [with regard to] the days and nights of the two [?] — their measure [is] close, one to the next in reckoning, as will be explained further on.

134§ — סימן קל"ד: on explaining that the sun's circles are not perfect circles

[Heading, p. 87, right column:] "We will explain in it that the sun's circles are not perfect circles."

Know that all the sun's circles mentioned are not perfect circles from point to point; for each circle draws away [?] from the next, and in the oblique [direction] sometimes [by] close to one degree, 40 [?] [minutes], of the sphere [?], and sometimes by about half a degree — at one time adding, at another subtracting... as [the sun at] Aries [טלה] is [?] at the [end?] upon the horizon [?]... upon the horizon on the morrow, or [on] the day, its circling [is] a full circle — but because the sun goes [set?] in [its] spheres beneath the sphere of the signs, as [was said] above... therefore this circle is not a perfect one from line to line; rather each circle draws away from its neighbor a little, on the side, according to the obliquity by which the sun draws away in its course beneath the circle of the signs, by one day, from the equator, or draws near to it. And picture to yourself the aforementioned circles as if you took a thread [?] [of length] 30 [ל'; [?]] and turned it about [?], [seeing] that in all these circlings there is no perfect circle from a whole line — rather the end of each circle draws away, [as it were] *coppo/copula* [קופן מרלטיקו — foreign term, garbled [?]], a little from the side.

135§ — סימן קל"ה: on explaining that the shared circles are exact only at their beginning

[Heading, p. 87, left column, folio 43=מג:] "We will explain in it that the sun's shared circles are not exact, in strict precision, except at their beginning."

Know that, according to what we already explained above — that the sun's circles are not perfect circles, but only a little [?], their end [differing] from their beginning — therefore know now that the sun's shared circles are not exact except at their beginning; for at their end the two circles separate and draw away, one from the other, by [about] the distance [covered] in one hour [?]. This is because the circle rising [?] at the head of the sign Aries [ראש מזל טלה], for

example, circles upon the equator, and forthwith [its] power bends a little, curving slightly, and inclines toward the north; and after 24 hours [כ"ד שעות], like a full [solar] day, [that] circle [is complete] — (because the sign [?] inclines to the greater obliquity) — the end of the circle overshoots its beginning by more than one degree from the equator toward the north; while the circle preceding it at the head of [the corresponding sign], which is [now] on the equator, forthwith also bends a little, curving slightly, and inclines to its order, and after 24 hours, when its circle [is complete] for the day, its end overshoots its beginning by more than one degree from the equator toward the south — so that the difference between the two ends of the shared circles [amounts] to more than two full degrees. And by like comparison in the others, there is always some difference between the two shared circles — even between the circles of Gemini and Leo [גלגלי תאומים ואריה], and between the circles [at] the head-degrees of Gemini [?] and the end of the first degree of Cancer [סרטן], each of these beside the other.

From all the aforementioned matters there is explained to you the measure of the days at the two heads of the seasons — the tekufah of Nisan and the tekufah of Tishrei — [which] are equal, one to another, in their measure, in complete precision; for there is between them some difference [?], by which one exceeds the other, as will be explained to you further on, in §140 [סי' ק"מ]. And it remains for you to know that the 182 [קפ"ב] circles which the sun makes from the head [of Aries] to the head of Cancer [ראש סרטן] are the same ones it passes, turns, and re-traverses — the [same] 182 circles which the sun makes from the head of Cancer to the head of the sign Capricorn [ראש גדי המזל]. For example, the circle which the sun makes at the head of the sign Aries [ראש מזל טלה] inclines toward the north; so too the circle which the sun makes, after half a year, at the end of the 29th degree [סוף מעלה כ"ט] of the sign Virgo [מזל בתולה] inclines toward the south — although, of necessity, its power inclines, and it uproots [i.e. supersedes] the circle of Aries and inclines it aside to [the other] side; and so it is with the others.

136§ — סימן קל"ו: on explaining that the sun's circles are not equally near and far to one another — and needless to say [unequal in] their obliquity

[Heading, p. 87, left column:] "We will explain in it that the sun's circles mentioned are not near and far equally, one to another — and needless to say [not equal in] their obliquity."

Also know that the sun's circles mentioned are not near and far, one from another, by an equal amount or measure; for in every circle it draws near [to], [and draws] away from, its neighbor according to the amount of the obliquity, as was mentioned above in the Fifth Section — for at the place of [?] Nisan [ד' ניסן [?]], and likewise at the place of Virgo and Libra [בתולה ומאזנים]...

[continues, p. 88, right column:] ...and [at the] the solstices [?], since they are [nearer] to the greater obliquity, the circles will there be [farther apart] [?]; whereas at the place of Gemini and Cancer [תאומים וסרטן], and likewise at the place of [?] and Sagittarius [קשת], the circles will be near and almost touch one another; and in all [these] the obliquities of the circles themselves [differ] — for all the circles [?], apart from the equatorial [day], whether [inclining] to the north or to the south, in every place, according to its nearness to one of the [two] poles, so [much] the smaller will its [circle] ever be, [reckoned] as a whole [?], from [?] the body [?], toward the equator [קו הישר [?]].

137§ — סימן קל"ז: [that the day-arcs incline southward and the night-arcs northward, for northern dwellers]

[Heading, p. 88, right column, running header שער ו:] "Know that the semicircle of the equator [קו הישר] which is above our horizon, and likewise the rest of its circles, that is, the day-arcs [קשת הימים] which the sun makes by cause of the daily motion — all these, for us, most of the dwellers of the world who inhabit the north, incline from the climes above our horizon toward the south, and are for us as [?] *quarantoi* [קירנטוי [?]]. And the night-arcs [קשת הלילות] which are below our horizon all incline toward the north — even the night-arc of the winter solstice [ליל תקופת טבת], which is joined to the circle of Capricorn [עגול גדי], whose day-arc is at the extreme of distance from us toward the south — the arc which is beneath our horizon inclines, according to our standing [i.e. our latitude], toward the north; and the measure of the inclination is according to a person's distance from the equator toward the north: the more our northerly [distance] grows, the more the inclination grows for us; so that for those who dwell beneath the northern pole [ציר הצפוני], the equator is their horizon, and the circles gird it like a belt girding [the loins of] a man. All this you may see, as it were with the eye's own perception, plainly.

And [see] how sweetly the words of the sage Israeli [Isaac Israeli] agree, in chapter 12 [פרק י"ב] of [his] book [?], with [this] — where he says [?], as it were "he crosses over" [?], and as it were [?], as [our Sages] expounded [?]: "[the sun] goes toward the south [by day] and circles toward the north [by night]," which, by the [?]... — the utmost of what is manifest and visible to our eyes. For just as the

sun is ever found each day [rising?] in the east, making one circle, and part [?] upon the western horizon… it [screens/covers] all night opposite the [day-]circle. [?]… as a disciple [?]… [circles?] open [?]… and as its course by day, so is its course [by night]… and thus, on the northern side [beneath the pole], it has no motion or path [distinguishing] between day and night [?]… for it does not pass over the circle of Cancer [עגול סרטן] of the [inhabited] world… on account of which many have opened their mouths against the dictum of [our Sages, of blessed memory]; [but] according to this [account], that eighth [?] motion mentioned, of all the inhabitants of the world… that some climes have days [ever set] toward the south, and the [night-]arcs ever toward the north — [these people] examined the words of our Sages, of blessed memory, [and found them] in the fullest of exactness [כתכלית הצודק], and returned and interpreted them as [our Sages] of blessed memory [intended]. "How [pleasing are] the source of his words, [how sweet] to my palate" [cf. Tehillim 119:103].

Incidentally [אגב], I saw fit to explain, in this place, what [we wrote above [?]]: [the verse] "[the wind] goes toward the south and circles toward the north" [Koheles 1:6]…

[continues, p. 88, left column:] …the plain sense of the verse is this: when the sun circles among the northern signs — for then it draws near to the inhabited world — it says "circles toward the north"; because in no verse [?] does [Scripture] impose upon us a circling in [only] a far-off place, for the encircler and the encircled are ever near, one to the other, as in "round about [סביב] the Tabernacle," "you shall cover [וסכות] the [ark-cover?]," "and [it] bounded [?]," and many like them. So too, when the sun circles among the southern signs — for then it withdraws from the inhabited world — [Scripture] says "goes toward the south"; for we find "sovereignty" [expressed] by way of a hint [רמז], as in "he walked in [embroidered work?]" [?].

138§ — סימן קל"ח: on explaining that for those who dwell beneath the equator, the length of day and the length of night are always equal

[Heading, p. 88, left column:] "We will explain in it that, for those who dwell beneath the equator [קו השוה], the measure of the day and the measure of the night are always equal."

For all those who dwell beneath the equator, their horizon divides the equator — and likewise the circle of the signs [קו המזלות] — each of them into two equal parts: the part which is for them above their horizon is called the day-arc [קשת

היום], and the part which is for them beneath their horizon is called the night-arc [קשת הלילה]. Accordingly, all the host of the stars — and the sun too, together with them all — when they circle the terrestrial globe by cause of the daily motion, the time of their circling above the horizon, each day, is found, for those dwelling beneath the equator, [to be] equal to the time of their concealment beneath the horizon, all the days of the world. And so the measure of the day and the measure of the night are always equal, each of them twelve hours [י"ב שעות] at every time; and [they know] no danger [?] of cold or heat, summer or winter; and one does not exceed the other — neither the day over the night, nor the night over the day — even in the days of the summer and winter solstices [תקופת תמוז וטבת]; and they have no variation, only the precedence of the tekufah for the people of the east and its delay for the people of the west.

And [for] those who dwell outside the equator, whether toward the north or toward the south — here too, day and night, joined together, are for them twenty-four hours [כ"ד שעות], just as for those dwelling on the equator, only that one exceeds the other: sometimes the measure of the day exceeds the night, and sometimes the reverse. And this variation comes from [the north?]... according to the inclination of the dwellers of a portion [of the earth] away from the equator toward one of the poles: so much do the days and nights lengthen and shorten for them; and the cause of the lengthening of the day and night for those who dwell beneath [any of] the degrees [of latitude] is entirely according to the time of the year, as will be explained shortly.

139§ — סימן קל"ט: on explaining that, on the days of the two equinoxes, day and night are equal, also for most of the other inhabitants of the world

[Heading, p. 88, left column:] "We will explain in it that, on the days of the two tekufot, day and night are equal, also for most of the other inhabitants of the world."

Two days are found in the year which are excepted from the [general] rules mentioned, on which day and night are found equal for all the inhabitants of the world, in all the climes, just as for those dwelling on the equator [line]; for these are the two days of the tekufah of Nisan and the tekufah of Tishrei — the true equinoxes [as poles?], on which the sun enters the sign of Aries [טלה] and the Scales [Libra — מאזנים]. And the reason [is] that, on those two days as mentioned, the sun circles upon the equator [קו הישר]; and it has already been explained above, in the Second Section, §39 [שער השני סי' ל"ט], that all the great circles

which pass through the center of the world are ever divided, each with the other, into two equal halves. It follows, by this, that the equator divides [?] every horizon [?] of the sphere of the world into two equal halves — since both of them are great circles; and close to this, likewise, that all... the signs which circle for them [by day], and likewise the sun which circles for them by night [when the sun...]

[§139, continued from the previous folio.] ...so that the sun is always opposite one of them.) And since its revolution above the earth equals its revolution below the earth — exactly as is the case for those who dwell precisely beneath the equator — by all these considerations it works out eye to eye [i.e. exactly equal]. It thus appears that all the aforementioned inhabitants, in every place, have their day-arc equal to their night-arc [on those two days]. Were it not for these two mentioned days [the equinoxes], it would never be found that day and night are equal for the [world's] dwellers throughout all the days of the year; nor would any of the climes be found equal in this respect. Rather, in each of them one [arc] always has some excess over the other; and even [comparing the several regions], they are never found equal to one another in their measure in any place — except as stated above.

סימן קנ"מ (§140)

Explaining that the measure of the daytime of the Nisan tekufah exceeds the measure of the daytime of the Tishrei tekufah.

Although in all the books I have found the measure of the [day of the] two tekufot, Nisan and Tishrei, [treated] as equal to one another — as [being the] mean [values] — because [at those points the sun] circles upon the circle of the equator, nevertheless I say that when one examines closely the revolutions of the two days of the two tekufot, it is found that the day of the Nisan tekufah exceeds the day of the Tishrei tekufah by a small amount. This is as was already explained above in §135 [קל"ה [?]]: that of the two signs Aries and Libra, [at the one near apogee] the sun is more distant [from the earth]... [several words garbled: sense is that the difference plays out over the 24 hours]. Therefore know that the sun makes its circuit from the head of Aries in the span of 24 hours [moving] like a thread [along the equator], and in the time it travels along its slanted path one degree toward the north, in that same time — within the revolution of 24 hours — the day-arc is lengthened for us over the night-arc by some small amount [שיעור מה [?]]; and [correspondingly, when it moves southward] the night-arc is lengthened for us over the day-arc, within that revolution of 24 hours, and the daytime is shortened for us by that measure.

סימן קמ"א (§141)

I inform herein that the natural [solar] days are not equal in their length.

We have already explained above [§? — reference garbled], and it will be further clarified below in §184 [קפ"ד], that the measure and span of the year, according to the view of the astronomers, is 365 days, 5 hours, and [?] minutes [שס"ה יום ה' שעות כ״ה/כ״ט דקין — minutes uncertain]. If you divide the 360 degrees of the heaven by the number of days of the solar [year], the mean daily motion comes out to about 0°59′8″ [נ"ט דקין ח' שלישיות] per day. At first glance it would seem that a day-and-night of such uniform measure should hold for every day, always equal. But know that this is not so: for we find a great and distinct difference between one natural day and another. As was already explained above, in Section Five, in §116 [קי"ז [?]], concerning the tractate of the inclination of the sphere of the zodiac — some [signs] rise in longer [times] and some in shorter [times]. [This is the first cause.]

Know that this difference, for those who dwell beneath the equator, is a small and fine difference — so slight that it is scarcely perceptible and cannot be registered by [ordinary] sense, though reason and demonstration attest to it; whereas for those [who dwell] beneath [other latitudes] this difference is felt even by sense, as you will observe above in the previous section, in the table of the rising of the signs [and their setting]. This becomes clear when you combine the times of a sign's rising and setting: for the sign of Cancer, the measure of its two [risings/settings] is some five hours and 14 minutes in [equal] hours [ה' שעות וי"ד דקים [?]], the difference [between them being] about half an hour.

And there is yet a further point for you to know: the second, [more] necessary cause — namely, that the natural days differ slightly in their measure — is on account of the variation in the sun's own course, since [the sun] revolves [with non-uniform motion]. [Remainder of the paragraph continues onto p. 90; the sun's varying speed makes successive natural days unequal.]

סימן קמ"ב (§142)

We inform herein of the causes of the lengthening and shortening of the days for us, the dwellers of the north, throughout all the days of the year.

Know that for us, who are inclined away from the equator toward the north, our horizon divides all the [diurnal] circles that the sun traces by its daily motion into two unequal parts: the day-arc, which lies above the horizon, and the night-arc, which is beneath the horizon — but not into equal parts. As the sun's position

recedes from the equator toward the south, the night-arc immediately begins to exceed the day-arc for us. From this it will become clear to you that all the circles the sun traces while in the northern signs (which are Aries [through Virgo]) yield a day-arc greater than the night-arc for us; while all the circles it traces in the southern signs (which are [Libra through Pisces]) yield a night-arc greater than the day-arc. And as a general rule: …it would not be found for us [that day equalled night] were the setting of this and the rising of [that separated] only by a revolution of 150° [קן"ו — but the arithmetic below requires 120° [?]; see numerical note], [together with] 240° [ר"ם]… a revolution of [some] hours, reckoning 15° per hour [ט"ז/ט"ו [?]], and likewise always [dividing the arc by that rate]; so that at [the sun's] setting there is found a revolution of 240° [ר"ם] — a revolution of 16 hours. [At the Nisan tekufah the sun] turns its face toward the south [or toward the north], and the days go on drawing nearer and shortening, until the sun reaches the sign of Capricorn, which is the point most distant [from the north]; then the measure of the daytime is at its very shortest for us, because its day-arc is the smallest of all arcs, and its night-arc is the longest of all night-arcs.

[§142 continues on p. 90, closing with a self-note:] And I set this down as a marker, a reminder to myself, until I investigate it further — §142 [קמ"ב], [as noted] elsewhere [בפל' — abbreviation uncertain].

סימן קמ"ב (§142 — duplicate number as printed; logically §143)

[Explaining] that the measure of the weekdays' daytime is never equal to the measure of its own night; and likewise its daytime is never equal to the [corresponding] weeknights.

Many suppose that the measure of the daytime [at one tekufah] is always equal to the measure of the nights that fall at the [opposite] tekufah — that the daytime at the Tammuz tekufah [summer solstice] equals the nighttime at the [Teves tekufah, winter solstice]. But the matter is not so: for when one finds [the arcs of the] tekufot… [several words garbled]… the [day] is lengthened for us [beyond its counterpart by a small amount, on account of the eccentricity explained in §140].

סימן קמ"ג (§143 — printed קמ"ג; logically §144)

Explaining that for some people the measure of their daytime will be twenty-four hours.

Know that for those people who are inclined away from the equator by 66°[30′ [?] — printed "ס' דקין"] toward the north — for whom the sun, on the day of the [Cancer] tekufah [summer solstice], does not set beneath the horizon at all — the measure of their day at that time will be like a full workday of twenty-four hours. Regarding this we must recall what was already stated above in [an earlier] section, in §[102 [?]]: that the northern circle [i.e. the Arctic Circle] merely marks the trace [drawn] about the axis of the world, standing off from it by 23°38′ [כ"ג מעלות ל"ח דקין — the obliquity of the ecliptic]. It was also explained there, in §[?], that [when] the equator['s farthest point] is at the head of Cancer, which is inclined [to its maximum]… the sun [remains above the horizon the whole revolution].

סימן קמ"ד (§144 — printed קמ"ד; logically §145)

I inform [herein] that in some countries the measure of the day is one month, or two months and more; and likewise the measure of the night.

For those who dwell farther still beyond the northern [Arctic] circle, toward the axis of the world: in proportion as their dwelling approaches the northern axis, so much more of the arc about the point of the head of Cancer — together with the neighboring signs on its two sides — projects and remains above the horizon and never sets there. So long as the sun revolves along its path through the degrees of those signs that remain above their horizon, they have continuous daytime, and in that period they have no night at all. If the portion that remains [above the horizon] together with the head of Cancer, on its two sides, amounts to the measure of one sign, they will have one [month] whose whole measure is daytime; and if that portion is the measure of two signs, they will have a daytime of two months [—] and so on, so that some will have a daytime of three months; and the reverse of this holds for them [in winter], when — with the arcs of Capricorn and Aquarius — they will have a night of three months.

The sun's [dwelling above the horizon] increases by about four degrees [in such regions] (as in the countries of Norway [נרוך [?]] on the one side, and the country of Muscovy [מסכנל [?] — identification uncertain]).

And I have seen, [recorded] in books, [an account] of a deed that took place in this matter about three years ago [כמו שלש שנה [?]], in the great city of Amsterdam [אמשטרדם], the chief metropolis in the land of Holland [האלנד]. A company of many men, among them great and renowned scholars, filled their hearts to go exploring and to survey the northern sea and the dwellers of the northern world. They fitted out for themselves a great and mighty ship, and gave it, moreover,

[stout] heart and much spirit; and they went forth from the great city of Amsterdam and went down to the sea and sailed [northward] — which is along the length of the world, from [one] extreme… [reaching] ninety degrees [תשעים מעלות [?]], and being about 74° [ע"ד מעלות] from the equator — and there the sun set upon them beneath the horizon and could no longer [rise], [and their ship] froze in [the ice], and they dwelt there many days [before many men perished — sense of the abraded close].

סימן קמ"ה (§145 — printed קמ"ה; logically §146)

That in some places the measure of the daytime is four months, and likewise the measure of the night.

For those who dwell from there onward, toward the northern axis, a further [three degrees], being about 77° [שבעים ושבעה מעלות] from the equator: there [four] signs — which are [Aries through Cancer, or the like] — remain always above their horizon, and the four signs opposite to them are always hidden from them. [For four months the sun traverses the ever-visible signs and they have continuous daytime; for the four months it traverses the hidden signs they have continuous night. The intervening details of degrees are given but are partly abraded.]

סימן קמ"ו (§146 — printed קמ"ו; logically §147)

That the dwellers beneath the northern pole have a daytime measure of six months, and likewise a night measure [of six months].

For those who dwell beneath the northern axis — that is, where the axis itself would be [directly] at the point opposite the zenith over their head — [the pole is at their zenith]. On reflection, the circle of the equator [there] becomes the [horizon], and [the celestial equator lies along their horizon]; [the whole revolution] of the light of the signs about them resembles the turning of a millstone [i.e. the sun circles parallel to the horizon]. As was already explained, the equator divides the sphere of the zodiac into two halves… [each sign at its declination of up to 23°33′/38′ [?] rises above or sinks below]. So long as the sun is within the northern signs, they have the light of day; and this lasts half a year. And when the sun is within the southern signs [they have night] — for a natural day, always continuous, will be for these inhabitants the light of daytime for half a year, and the darkness of night [for the other half].

סימן קמ"ז (§147 — printed קמ"ז; logically §148)

To inquire and to know, in general, the clear determination of the lengths of the days — [both the] long and the short — for all the days of the year, in every place and every time.

First you must know, for the day inquired about, the sun's place [in the zodiac] according to the [tabular] method [of the sphere of the signs] — for [only] the general [figure]… [Then find] the point of the meridian [nogah ha'ir] over the place for which you inquire, and reckon until [the ecliptic degree] reaches [the horizon]… Take the [ecliptic degree] rising on the eastern horizon and [the one setting on] the western horizon; the [arc] between them upon the equator is the day-arc. And by the same method [reckon] the night-arc: the [arc] between the two [ecliptic] points [below the horizon].

By way of a worked example: the city of Prague [פראג], where the pole rises above the horizon about [50°] — when the sun is at the [summer] tekufah in the sign of Cancer, [its day-arc comes out to] 240° [ר"ם]; therefore divide the 240° into the twelve [temporal] hours, and each temporal hour is 20 equatorial degrees [עשרים מעלות]. [If instead you divide by the equal-hour rate of 15° per hour, the 240° yields 16 hours.]

So by this rule you will find the day-length there to be fourteen hours [i.e. for Jerusalem at the summer tekufah, 14 hours]. And when the sun is at the beginning of the sign of Capricorn, and you elevate [the pole] in the usual way, the day-length here in Prague comes out to eight hours, and for Jerusalem, by the same rule, you will find its day-length to be ten hours. I have seen fit to give the students in this matter the reckoning, both in general and in detail. [Their guide is:] if the first point [of the ecliptic] that sets does so exactly at the western horizon before the [next] degree sets among the signs where the sun is, then the measure of the daytime, at the present inclination, is longer than the measure of [twelve] hours — that is, more than 12 hours — and this is while the sun is within the northern signs. [The reverse holds in the southern signs.]

[The passage continues with the detailed Jerusalem/Prague computation: the day-arc reckoned in degrees, divided by 15° per equal hour to yield the hours; e.g. a day-arc such that the daytime is 14¼ hours, and the corresponding latitude of Jerusalem taken as 32° [ל"ב מעלות [?]]. Several numerals in this stretch are abraded and are flagged.] …and thus for Jerusalem, [§]26 [כו' — cross-reference or "etc.," uncertain].

סימן קמ"ח (§148 — printed קמ"ח; logically §149)

On the differences found among the inhabitants of the world in the beginning of each daytime, and [in] the moments and instants of midday — a general rule.

By reason of the sphericity of the earth, many differences and distinctions are found among the inhabitants of the world in the beginning of each daytime and the beginning of each nighttime, and likewise at the instants of the [moments] of midday: there is a precedence of the eastern [dwellers] over the western, and of the northern over the southern. These differences and distinctions are found in four respects, and these are they: (1) for [the dwellers] beneath the equator; (2) for those who share the [same] terrestrial latitude; (3) for those who share [the same longitude…]

(Continuation of סימן קמ"ח [§148 printed; logically §149], on the differences among the world's inhabitants in the moments at which day and night begin and at which midday and midnight fall — the fourth of its four respects.)

The fourth respect: those who share neither their longitude nor their latitude. From here on I shall treat them in order, in a compressed presentation. This subject touches on the small differences [among places], and I have alluded to it further — the Chacham Yisraeli [Isaac Israeli, *Yesod Olam*], in Book 2, chapter 16 [?], in a passage where he unfolds something of this. Tabakiski [?] did not treat this matter at the length the subject deserves; therefore I do not presume to speak of it with precise exactitude, but only so far as my own eyes can see and as far as your understanding will reach — until you add further inquiry and expound the subject well.

סימן קמ"ט

[§149 printed; logically §150] — The rule of precedence and delay for those dwelling under the line of right position [i.e., on a single meridian / the celestial equator].

Concerning this matter we have already set out our words above in several places. Nevertheless, since this siman brings all four aspects together in due order, I saw fit to restate this rule here, for this is its proper place.

Know that for the dwellers under the equator — at the beginning of their day and night, at the moment of their midday, and at all the other hours of the day — precedence belongs to those to the east and delay to those to the west. The

measure of that precedence and delay is proportional to the distance between them: for every 15° of separation, the easterners precede the westerners by one hour. Thus the difference between those at the far edge of the east and those at the navel of the earth [the mid-point] — a distance of 90°, a quarter of the globe — [is a set interval]; and when it is the start of day for the dwellers at the navel of the earth, it is already midday for those at the eastern edge and midnight for those at the western edge. The distance between the eastern-edge dwellers and the western-edge dwellers, being half the circumference of the globe — 180° — yields a difference of 12 hours between them. So the start of day for the one in the east is midnight for the one in the west, and the edge of day for the one is midnight for the other, and vice versa. In this way all of them always have their [alternating] days and nights.

סימן קנ"נ

[§150 printed; logically §151] — Those who share the same latitude have the same length of day for all of them.

Places that share their latitude — that is, that lie at an equal distance from the line of right position [the equator] — even though they are far apart from one another to the east and to the west, have one and the same measure of day and night, exactly as it is for all who dwell under the equator, where a single rule holds for all its inhabitants. Even if one is distant from another by [several] parsangs [to the north — recte: to the east/west], there is no difference between them save the precedence of the easterners and the delay of the westerners, at the rate of one hour for every 15° of the distance between them — just as it is for those who dwell under the equator.

סי' קנ"א

[§151 printed; logically §152] — Places that share the same longitude have the same moment of midday for all of them, but not the same beginning of day and night — except at the equinoxes of Nisan and Tishrei.

A line running straight from north to south [a meridian]... (and so too the antipodes, in latitude [?])... has already been explained above, in the Second Section, siman [36§] ל"ו: midday is shared by all of them on every day of the year, and the [same] fixed stars [culminate over them], and the moments of the equinoxes of Nisan and Tishrei [are common to them].

And likewise, from what has been explained — that the moment of midday is common to all [places on the meridian] at one and the same instant — at first

glance it would appear, and it would seem to us, that the rule for the beginning of the day would be the same as for the midday line, since they are all fixed upon a single meridian running from north to south, whose whole length from its head to its end shares one [culminating point of] the east. But know that in truth the matter is not so, and it cannot be — for the sun does not rise and set for them all at once, with the [same] precedence and delay [that governs midday]. The sun does not rise for them all in a single instant, except on the days of Nisan and Tishrei [the equinoxes]. For all who dwell [along a meridian] incline toward one [pole], and in the summer the day-arc of the northerners is larger than the day-arc of the southerners. Necessarily, then, in summer the sun rises earlier for the northerners than for the southerners — by half the surplus arc added each day to the northerners over the southerners — and it likewise sets later over the northerners than over the southerners. Were we to say that it rose and set for them all at once, then day and night would be of equal measure for all of them — and that is an outright falsehood.

The precedence of the sun's rising for the northerners over the southerners is proportional to the [half of the] surplus day-arc that the northerners have over the southerners. Accordingly, to my mind, one must [know] the altitude of the pole [the latitude], that is, the distance from the equator, of each and every one of the aforementioned places, by the method explained just above. Now we have found that the distance of the city [רע"ב — garbled proper name; a far-northern city] from the equator is 61° [61 = ס"א; reading uncertain]; the distance of the city of Vilna from it [the equator] is [25 = כ"ה as printed — a probable kaf/nun misprint, since Vilna's latitude is ≈ 55° = נ"ה] [?]; and the island of Corfu [is] 38° [38 = ל"ח] [?] from it. According to their distances — for the equator [is the reference from which] their pole-altitudes [are reckoned] — and when we compute, by their altitudes, the measure of their day by the method explained just above in siman [147§] קמ"ז, we find that the length of the day at the summer solstice (תקופת תמוז) is: in the city [רע"ב] [about] 19 hours [?]; in the city of Vilna 19 hours [?]; and in [the region of] Corfu 16 hours [?] and a third of an hour [?]. *[Reader's note: these three solstitial day-lengths and the three latitudes above are set in tiny, degraded type; the values are transcribed as read but several are internally inconsistent and are flagged uncertain]*

the [surplus] whose measure yields the surplus of the day-arc... two-thirds of an hour, and the surplus [of the westerners]... three hours... In the city of [Prague — רעב"ל/רפב"ל, garbled] [?], as [computed] by its altitude, [the day is] [x] hours... before [the moment reckoned for] Corfu... Regensburg [ברסבורג?] [?]... before Corfu... [the city of] Prague [פדגר — garbled for פראג] [?], [recorded here] as a

memorandum for the matter, in a well-verified [?] compilation, with full exactitude.

סימן קנ"ב

[§152 printed; logically §153] — Places that share neither their longitude nor their latitude — how many rules and laws apply between them, one with another.

Places that share neither their longitude nor their latitude — [I shall now treat them] in order. The Chacham Yisraeli [Isaac Israeli] discussed this matter in Book 2, chapter 15, though only a little, for [various reasons]; and other rules are hinted at, but they were not revealed to us — some of them remain obscure. [He wrote] that even if one [wished to specify] for each of them [its] constellation or its analogue, and if a man set his heart to detail every one of them as their rule requires, and to expand the discussion at length, this would not be to the students' liking, nor is there any great benefit in it for us. The Rav R' [גלמן — garbled name] [?] too says [that he answered us] on this in a responsum, [declining to elaborate] on these rules, because there is great [room for error] in them and one easily falls into mistakes; therefore I too have inclined away and passed over [the attempt] to enter deeply into them — let one consult them there in their [own] sources. Yet I shall go so far as to examine, to the best of my ability, and to state [the case] for places that share neither their longitude nor their latitude. For example, Jerusalem — which lies at longitude 66° [ס"ו] and latitude 32° [ל"ב]; and Prague [פרוג], which lies at longitude 36° [ל"ו] [?] and latitude 50° [נ' — reading uncertain; Prague's latitude ≈ 50°]. The difference between the two of them in longitude is [x] degrees, and in latitude [x] degrees [8 = ח'?]. Now, according to their latitudinal position... the precedence belonging to the dwellers of Jerusalem [is drawn out] over two hours, by a reckoning of [x] degrees per [hour?] [?] — because the city of Prague, inclining more to the north, has precedence over Jerusalem, since the difference in Jerusalem['s day-arc] is 14 hours [י"ד]... a difference of [x] hours, as above, whereby they have precedence because of the surplus of the day-arc between them... [as stated] above.

[Reader's note: the coordinate figures and hour-differences in this siman are set in small, worn type; the clearly-legible values (Jerusalem 66°/32°, Jerusalem day-arc 14h) are committed, the rest flagged.]

סימן קנ"ג

[§153 printed; logically §154] — That there are some western lands in which the sun rises before it rises in [the more] eastern ones.

From the matters we have mentioned it will become clear to you that there are some lands that are western and some that are eastern; and the sun rises upon them, [some] on known [days], not all at one instant, and it does not set upon them at one instant. And there are lands where the reverse holds — that is, [the sun] does not rise for them at one instant... it sets from over them [not] at one instant, [but] toward the [known] side... and, more remarkable than this, and a wonder: all of this concerns western lands in which, on known days, the sun rises earlier than it rises in the lands to their east. As an illustration: the city of Constantinople [קונסטנטינא — Byzantium/Istanbul], for instance, lies at longitude 31° [ל"א] and latitude 84° [פ"ד — a numerical impossibility for Constantinople (≈ 41°); flagged, probably a compositor error for מ"ד = 44 or the like] [?]; while Jerusalem, off to its east, lies at longitude 66° [ס"ו] and latitude 32° [ל"ב]. Now Jerusalem has precedence [in longitude] over Constantinople by 8 degrees [שמנה מעלות = 8]; and the city of Constantinople, by reason of its inclination toward the north, has precedence over Jerusalem by 12 degrees [י"ב]. And since Constantinople's inclination to the north is the greater, and it lies toward the west, its precedence over Jerusalem is greater than [Jerusalem's] precedence [over it]. It follows, then, that in Constantinople — which is west of Jerusalem — the sun will rise on a given day before it rises in Jerusalem.

And now let us inquire, as befits so pleasing a precision, in the craft of the [celestial] globe... the longitudes of [these two] cities at the [summer] solstice in the two aforementioned places, by the method explained just above. We take the measure of the day-arc in Jerusalem as 14 hours [י"ד], and in Constantinople a little under 15 hours [ט"ו]. Now had the two places lain on a single meridian, the rising of the sun in Constantinople would have been one hour [שעה אחת] earlier than in Jerusalem; but because they are close [in longitude] — Jerusalem having 8 degrees of easting over Constantinople, which 8 degrees amount to about half an hour [כחצי שעה] — the net remaining to us is half an hour, by which the rising of the sun in Constantinople (the western city) precedes its rising in Jerusalem (the eastern). So it appears to me, and the whole [reckoning] is in close approximation.

סימן קנ"ד

[§154 printed; logically §155] — That the sages agreed to reckon the times of events by the moments of midday and midnight.

Yisraeli [Isaac Israeli] wrote, in chapter [ס"ה = 65?] [?] of [his] Book Two, that the sages of [reckoning] agreed to base the calculation of the differences of the times, and to relate the times of events and deeds, upon the moments of midday and

midnight — [saying,] for instance, that on such a day an event occurred in the morning [reckoned as] so-and-so many equal hours before midnight, or so-and-so many equal hours before midday, [and so] throughout all the days of the year — [and this holds true] even for places that share neither their longitude nor their latitude. For example, between Jerusalem and Prague there is precedence and delay in the beginning of day and night, always by one fixed measure and reckoning: one hour for every 15 degrees. And there is no difference in this between the dwellers [on or off] the equator; rather it is always thus. But if they [chose to] relate events to the moment of sunrise or sunset, or [to] any [other] need — [given] the many rules and conditions that lie in astronomy — it would be a great and easy thing to fall into error. All this concerns those who dwell [in different latitudes] and share neither their longitude nor their latitude. But as for the shared latitude of two places [that dwell like those under the equator], there is no difference there between reckoning [an event] from midday or midnight and reckoning it from the moment of the sun's rising over the horizon or from the moment of its setting — because all the horizons of [places on] the equator are, throughout the world, [each] a midday-horizon [for others]. For example, the horizon of those at the navel of the earth is itself the midday-line [meridian] of those at the western edge, and likewise for those at the eastern edge; and so is the rule for all the horizons of the equator — they are all midday-horizons [for those who share latitude]. There is no difference in this reckoning as to whether the calculation is tied to the moments of midday or midnight, or to sunrise and sunset, for their rule in this is as the rule of all the dwellers of the equator, as we have said.

סימן קנ"ה

[§155 printed; logically §156] — The reason for the precision in knowing the aforementioned differences.

That which the sages of astronomy were so precise about — the knowledge of the differences of the times among the inhabitants of the world — was not merely to sharpen the students thereby, so that man's superiority over the beast might be [made manifest]... [but rather] for many matters, as will be explained. For us too, the House of Israel, there are things at stake in this — for instance, the matter of the seasons (tekufot) of the constellations. Suppose, for example, we need [to reckon] the Tekufah of Nisan, and it falls at the completion of Shabbos day [?]; since the tekufah occurs at one [and the same] moment for the whole world entire — how then can it be that at one and the same instant it is midday of Shabbos in every place on earth? [Rather,] we are, as it were, [only] a small share

[of the world] at the hour of the tekufah, [and] we must know for which place on earth the reckoning of the tekufot was established. And it is, as stated, that its foundation was fixed upon the horizon of Jerusalem, where the tekufah falls at midday of Shabbos. If so, we must calculate what time this is here in the city of Prague; and we find, by the reckoning, that at that moment it is two hours before [midday] for us, and in the far west it is about 4 hours and one-fifth of an hour before [midday]. We derive great benefit in this matter from the reckoning of the tekufot as regards the intercalations (ibburim / evronot), and in the reckoning of the molads (conjunctions), of which we shall yet speak further on, in the Eighth Section.

Another illustration of the usefulness of knowing the differences of the times: it is already well known that lunar eclipses have [great value] for recognizing [longitudes] — [there are] many great benefits in [this], for knowing the boundaries of the earth, for knowing the times, for knowing the moments of the molads, and [for knowing] the courses of the [planets, the] "kings" among the stars.

סימן קנ"ו

[§156 printed; logically §157] — On the variation of summer and winter, and that those dwelling on the line of right position [the equator] have two summers and two winters.

In the [matter of the] seasons of summer and winter we find variation and difference between every place and every place among the inhabitants of the world. For all who dwell between north and south, [in the register] of the lengths of the days, there will be found variation and difference between each and every one of those who dwell between north and south, according to their nearness to and distance from the equator, as above. Just so will be found among them variation and difference in the season of summer and of winter, according to their nearness to and distance from the equator. Let us begin with an account of the occurrence of summer and winter for those who dwell under the line of right position — the middle [line] between north and south, which is the equator.

Know that all who dwell under the equator have two summers and two winters in each and every year. The two summers occur when the sun is at the head of the constellation Aries (Taleh) and at [the head of] Libra (Moznayim) — for then [it passes over their zenith]... [these are their two] seasons, each of which [brings its own summer].

the sun passes over their zenith (קדקד), and then, in each of these two times, they have the utmost heat, with the mid-point [of temperateness] between them. And the two winters are when the sun is at the head of the constellation Cancer (Sartan) and [likewise] at the head of Capricorn (Gedi); for at these two [times] the sun stands opposite the point of their zenith at its utmost distance, and this [gives] them, at each of these two places, [the depth of winter] — the first [winter] at the summer solstice (Tekufat Tammuz), and its middle [phase]... and the two winters at the utmost distance, like the cold [of...].

סימן קנ"ז

[§157 printed; logically §158] — Those dwelling to the side of the line of right position also have four turnings and four shadows.

between the tropic of Cancer (עגול סרטן) and [the equator] — those who dwell between the tropic of Cancer and [the tropic of Cancer... i.e., within the tropics] have four turnings [of the sun], two summers, two winters, and four shadows, just as those who dwell under the equator have; except that the times of the turnings and of the [two] winters are not at one distance, one measure, and one time [as they are on the equator], and in this they differ from them. For example: those who dwell in the middle, between the [equator] and the tropic of Cancer — when the sun is at the middle of the constellation Taurus (Shor), which is the midpoint between Aries and Cancer, it will be above their zenith, and this will be like half [of their first summer]... [and so] they will have their first summer, and [again the like] when the sun reaches the constellation Cancer at the new moon (Rosh Chodesh) of Tammuz [?]...

סימן קנ"ח

[§158 printed; logically §159] — The nature of the summer and winter sun for those dwelling under the tropic of Cancer and beyond it.

For those dwelling under the tropic of Cancer, the sun passes over the point of their zenith once a year, and then their day-measure is 24 hours [כ"ד שעות], per siman [80§ = פ'?] [?]; so it is, as above, for all who dwell [there], [where] days and nights are equal for each and every one who is in the middle [of that circle]. And likewise under the tropic of Capricorn (עגול גדי), in the reverse [season]. And in the middle [the equator], by day one will have no shadow at all, because all shadows stand upright and erect in a straight line... [and there is] only one summer and one winter. Just so will it be for all who dwell from the tropic of Cancer onward toward the north: the sun will not reach the point of their zenith [nor go] onward toward the north, as [stated] above, in siman [40§] מ'.

סימן קנ"ט

[§159 printed; logically §160] — Why at midday [it is] hotter than in the evening; why in the evening it is hotter than in the morning; and why it is colder in the season of winter than in the season of summer.

It is already known that the sun of the day [heats] by reason of the flashing of the sun's rays, on account of which it is called in Scripture *chamah* ["the hot one"] — as [the matter of] warmth [was explained] above, at the head of the First Section. (And according to the view of the philosophers, who said that in the celestial spheres there is neither cold nor heat, neither moist nor dry — let their opinion stand in its place.) For the sun's heat is felt on account of [several] causes. The first: that throughout the whole time the sun is above the horizon — which is the time of daytime — it is hotter for us than the time it is beneath the horizon. The second: that in proportion as the sun draws near to the northern pole, so the heat grows stronger for us who dwell in the north; and, correspondingly, in proportion as it draws away from us toward the south, so the cold grows stronger for us. We also know of the great heat found among those who dwell [near the sun] and incline toward the sun — such as Egypt [מצריים?] [?], the Barbary [coast] [ברבר"ס?] [?], and [the like] — not to mention the dwellers of the land of Cush (Ethiopia) and the dwellers of the land under the equator. And likewise we know [by report] concerning those who are far from the sun the great cold and the extreme [chill] that reaches those who dwell under the northern circle [the Arctic]...

[The siman continues into the following pages.]

(Continuation of 159§ / סימן קנ"ט — printed §159, logical §160 — begun in the previous pages: why the sun's heat varies by time of day and season.)

and the changes and moistening that come from it.

Now, since there is no doubt that by its nature the action of the sun in itself is always uniform, we have cause to wonder — for according to appearances its action seems to us to vary; yet it is the reverse that is the natural truth. For it is already known that the sun makes, each and every day, its daily circuit [כבת גלגל?] around the ball of the earth — this circuit being called the "day-arc" [קשת היום], as explained above. And since the day-arc stands at an almost equal distance from us, from the ball of the earth, from the moment the sun rises above the horizon until it sets from us, people are right to ask why the sun heats us more at midday than it heats us in the morning and the evening.

(2) And further: according to appearances, the opposite ought to hold for us, since — by its northward inclination, as will be explained better below — the sun is nearer to us in the morning and the evening, when it fills out the daytime hours.

(3) And further: why does it heat us more in the evening than it heats us in the morning?

(4) And further: why is it hotter after noon [אחר חצות יומם] than before, at the fore-part of the day?

(5) And further: why, when the sun is in the signs Cancer–Leo–Virgo [סא"ב = סרטן, אריה, בתולה], is it hotter than when it is in the signs Aries–Taurus–Gemini [טש"ת = טלה, שור, תאומים], even though in both its distance from the inhabitants of the world is equal, and day and night too are equal within the two mentioned periods?

(6) And further: since in winter — in particular at the winter solstice [תקופת טבת] — the sun is closer to the ball of the earth than at all the other times and seasons of the year (as will be explained ahead in the Seventh Section, siman [קע"ו?, ~ 176]), it would therefore be fitting that at the winter solstice, when it is near the ball of the earth, the air should be hotter than at the summer solstice [תקופת תמוז], when it is far from it. [Yet the reverse is the case.]

Answer. To resolve these questions, you must know the following.

First, that wind — that is, air — is by nature very cold; and were it not that the sun warms it against its coldness, who could endure? No creature, neither man nor beast, could stand before the frost and the great chill [הצינה].

Likewise, you must know that the degree of cold or warmth [reading uncertain — הסתימות] we feel depends on the sun's nearness to, or distance from, the point opposite the crown of our head [the zenith] — not on its nearness to, or distance from, the ball of the earth.

You should also know that the essential action of the sun's heat issues from the body of the sun itself, at its center.

Now that I have alerted you to these three known principles, we come to resolve the questions. Know, then, that when the sun pours its influence upon us onto the earth along a straight, perpendicular line — from directly above, straight down, as when it is near the zenith — it heats the air more than when it is far off and inclined away from the ball of the earth. For then the sun's rays go forth with power and strike the ball of the earth with great force; and when the ray

rebounds from the ball of the earth upward, the air is heated for us by day with extra heat. It is not so when the sun rises and sets, for then it shines upon us from the side, along a slanting line, and there is not in it that force just mentioned.

The sages already illustrated this with an analogy and a parable: an arrow thrown straight down, along a perpendicular, falls with great force and even rebounds and springs back upward toward the one who threw it; but when one throws it [slantwise], it does not fall with such force, nor does it rebound, but only skips and moves away from its thrower.

And now know that after the air has been chilled all night, in the morning, when the sun rises above the horizon and shines upon us from the side at a slant, it does not yet have force enough to heat the air that is above the horizon; in a moment it only warms it little by little, and the heat keeps increasing until noon, for then, on every side and in every place, the full force of maximum heat is present. Then, as the sun travels on and shines from the side at a slant, it lacks the force to heat as it did [at the day's height]. For this reason the air is hotter after noon than before, and in the evening more than in the morning.

From the reasons mentioned, you now understand why, when the sun is in the signs Cancer–Leo–Virgo [סק"ב = סא"ב], it is hotter than when it is in the signs Aries–Taurus–Gemini [טט"ת = טש"ת] — even though in both cases its distance from the inhabitants of the world is equal, and the times are equal. It is because, over the span of its travel through the three signs Aries–Taurus–Gemini, the sun has already warmed the air; so that over the span of its travel through the three following signs — Cancer–Leo–Virgo — it adds still more heat. This is like a furnace [מדורה?] kept burning from the morning until noon, which grows hotter still as more heat is added to it after noon.

160§ — סימן ק"ס

(Printed 160 = ק"ס; logical count §161. The final glyph of the printed number is malformed — see QA note.)

סימן ק"ס. That the cause of day and night, summer and winter, and the rest of the seasons of the year — all of them, too — lies in the two motions, the voluntary and the necessary [forced].

Even though the cause of day and night, summer and winter, and the other seasons of the year has already been explained to you in an earlier section, with reasons as needed, you should nonetheless know that the Israeli sage [R. Isaac Israeli, author of *Yesod Olam*] wrote, in chapter 8 of the Second Essay [reading

uncertain: בפ"ח ממאמר השני], that all the variations of day and night, summer and winter — in general and in particular — are due to the two motions, the voluntary and the necessary: the one being the voluntary [eastward] motion, from west toward east, and the second the western [diurnal, forced] motion... [and he explains that everything of the necessary motion belongs to the star/sphere that turns [הנוקב?] from east toward west]. And I say:

(§160 continues on the next page.)

Now I say: were the reverting cause — the one that [revolves eastward, אחור?] — [reading uncertain] and that turns from east toward west [to exist alone], upon the foundation that the daily [motion] alone gave from among the instruments of motion toward the east, then the sphere of the stars would give us, all the days of our existence, only rest and stillness. The stars of the eighth firmament that face our horizon would be visible, and all the stars beneath our horizon hidden, all the days of our existence; and there would be no change in the nature of the stars, but it would simply revolve, each and every day, upon a single circle, all the days [of the world]. No part of them would draw near opposite the zenith, nor recede from it, and there would be no reason nor occasion for any change of its season, no alternation of summer and winter; the days would not vary [in length] in one place, and there would be no difference for cold or [heat?], no renewal nor any other of the works of Creation.

And conversely, were the western sphere-motion — turning from the west — to incline alone in the eastward revolution by means of the daily sphere, then the reckoning of days would be entirely void, and there would be no light revolving [in alternation] because of darkness. On this account the sun would forever face us [at] the western horizon [reading uncertain], its light and heat spreading over it and never setting... and thus [in every place the portions of daytime and of night would be] uniform, and likewise for the other planets, each of which would have its [fixed] portion... [and its time] of setting beneath the horizon of each observer... nor would there be any occasion [for change]... nor any alternation of the divisions [of time]. Thus ends [the matter of] summer and winter.

§161 — סי' קס"א

(Printed 161 = קס"א; logical count §162.)

סי' קס"א. From which place each and every day begins to be called by its name.

A wondrous question — great, pleasant, exceedingly long and broad, deeper than the sea: to know from which place in the world each and every day begins

[reading uncertain] to be called first by its name, and which place in the world is the one where the naming of each day ends, as in the natural days. Great ones of the world were roused to this — among them Rav Saadia [Gaon], the precise investigator; Abraham bar Ḥiyya; the great R. Isaac bar Baruch; R. [Yehuda] HaLevi, author of the *Kuzari*; R. Zerachiah [HaLevi], author of the *[Sefer] HaMaʾor*; and [others,] may they be blessed. On this matter the great [האלנטינגון?, name garbled] already wrote... and R. Isaac Israeli, in chapter 17 of the Second Essay [reading uncertain: בפ' י"ז] of his book *Yesod Olam*, expanded at length upon it — several large pages, written [on both] their sides. He wrote that in these matters the earlier authors wrote according to the opinion of most people, and that the authors [themselves] strayed from the path of reason in what their spirit sought, and their reach fell short of bringing the judgment to light. And I have seen, in [various] books, in this passage, the substance of the aforementioned question... together with other hidden confusions, branching and cascading [one from another]... [so that] my soul became entangled... Nevertheless...

(§161 continues.)

[the sun stands] at the western edge, and it delays yet further the onset of Shabbos night for him. And it is a plain matter that, some hours later, the onset of Shabbos night will be for the one seated opposite the navel of the earth [its center] — that navel being so many degrees removed [reading uncertain] from the western edge; so that, accordingly, their [respective onsets] are [staggered]. And [again,] some hours later the onset of Shabbos night will be for Shimon, who dwells at the [eastern?] edge. (And thus, according to this, following the view of the author of the *Maʾor* and the author of the *Kuzari* mentioned above, the dwellers at the navel of the earth are earlier — when the holy Shabbos begins for them — than the dwellers at the western edge by [six?] hours, given that the distance between them is only ninety degrees, which the sun traverses in six hours [reading uncertain — see numerical note].)

And it would appear to us, by this reckoning, that after [a further span of] hours it would again become the onset of Shabbos night for Levi, who dwells at the navel of the earth — a second time. But this is a manifest falsehood: for how could it be that a sunset [the onset of Shabbos night] occurs at a certain place, and immediately, after twenty-four [24 = כ"ד] hours, at that very same place it should be the onset of Shabbos night a second time? This is vanity and vexation of spirit. We are therefore compelled to say that there is a place where each day begins to be called by its name, and a place in the world where that day comes to its end there — only, we do not know which is their location.

The [second] question. How many hours does the name "Shabbos" — or the name of any other of the days of the week — remain [in force] there, according to human reckoning, for all the inhabitants of the world who dwell along a single line [meridian] that runs from the west to the east, encircling the whole ball of the world? To explain, to make understood, and to give insight — for students — let us first speak of the semicircle-line of the ball of the earth, which runs from the eastern edge (where the head and the beginning of the numbering of the world's [degrees] is) to the [western] edge, completing one hundred and eighty [180 = ק"פ] degrees. And now let us make a supposition and say, by way of example, that Shabbos night has begun — the moment of the sun's setting on Shabbos [eve] — at the utterly eastern edge, and that it is [the moment of] the sun's standing opposite the navel of the earth... [the worked example continues here with a numeral-dense reckoning of degrees and hours; the individual figures are at the resolution floor and are flagged [?]].

The third question. Behold: when the center of the sun stands, at the ending of Friday's daytime, above the zenith of Reuben at the western edge, and we posit that it is then the moment of Friday's sunset for Levi who dwells upon the navel of the earth — and for Levi it is at that same moment the onset of Shabbos night (though it is not known to us whether the *naming* of the Shabbath day begins there, for it is possible that, some hours earlier, the onset of Shabbos night was already [reached]

(§161, third question, continues.)

at the eastern edge). And since Shabbos night begins for Levi at the navel of the earth, it necessarily follows that for Shimon, who dwells at the eastern edge, at this same moment it is midnight; and... [for the one] who dwells opposite the soles of [Levi's] feet [his antipode]...

Diagram. A circle bearing a horizontal and a vertical diameter (a cross through its center), illustrating the date-line thought-experiment of three observers stationed along an east–west line across the ball of the earth. Legible labels:

- ערב (outside the circle, top): "Evening."
- בקר (outside the circle, bottom): "Morning."
- Horizontal diameter, three observer-names (reading right → left): שמעון [Shimon] [?] · ראובן [Reuben] · לוי [Levi]. Per the surrounding text, Reuben is stationed at the western edge, Levi at the navel (center) of the earth, and Shimon at the eastern edge; the printed left-to-right placement of the

names on the axis does not obviously match that west–center–east order, so their exact positions on the figure are uncertain.
- Curved text around the perimeter (both arcs): present but illegible at this resolution [?].

Opposite the navel of the earth [i.e., for its antipodal dweller] there is for him [half an hour?] [reading uncertain]... the beginning of morning... It has not been made clear to us whether [that moment] is morning for them — whether it is morning there — as it is [morning] for those opposite whom the naming of each and every day begins... at their place [at] the navel of the earth. Hence, [some] hours after the moment of the onset of Shabbos night for Levi, who dwells opposite the navel of the earth (for whom, accordingly, it is morning when, at the sun's rising after it, the name "Friday" [יום הששי] is called)... And the same law itself [applies] when the naming of each day begins at the edge [where] it is likewise the "morning" mentioned — the morning of Friday... the days whose naming begins, each by its name, as "evening" opposite the navel [of the earth]. It follows from this that the onset of Shabbos night for Levi, who dwells upon the navel [of the earth], is twelve [12 = י"ב] hours after the onset of Shabbos night for the dwellers [at the antipode]. Accordingly, then, the aforementioned "morning" touches upon the morning of [Friday]...

The fourth question — and it is deeper, more perplexing, and more wondrous than all the other questions mentioned above. For it, let us posit a single point [reading uncertain — להרא"ש ולהריא"ף?] on the circumference-line of the ball of the earth — any point at all, since it makes no [practical] difference in the matter, for [all] points of the [earth's] sphere are equal in this regard... [taking a point on] the eastern [semicircle], and let us imagine as though there, for certain, the naming [of the day] begins...

Shabbos day. And it is already clear that it is a plain matter that, after [some] hours, the sun will set for Levi who dwells upon the navel of the earth; and after a [further] span of hours the sun will set for Reuben who dwells at the western edge — and that too is, for him, the onset of Shabbos day. Now let us ask about Yehuda [יהודא], who dwells opposite the navel of the earth [at its antipode]: when will the onset of Shabbos day be for him? Behold, at the [start of the] season it appears that his Shabbos begins some hours after the onset of Reuben's Shabbos — namely, seventeen [17 ~ ,?י"ז] hours after the naming of the Shabbos day began at the place of Shimon, who dwells at the eastern edge, as stated...

And behold, R. [Isaac] Israeli has already testified concerning the words of the two colleagues — R. Yehuda HaLevi [author of the *Kuzari*] and R. [Zerachiah,

author of] the *Maʾor* — regarding what they established as a foundation: that the beginning of each and every day, to be called by its name, is first at Jerusalem — that is, at the navel of the earth. And he answered them with decisive replies, difficulties, and great and awesome [objections], such as we raised above in this siman. He, of blessed memory, labored over it in his give-and-take [as one who] plumbs the mighty waters, and he held that all the doubts and confusions mentioned — which testify against the sages — [rest] entirely, according to their premises, all of them...

[Sixth Section — conclusion of Siman 161 (printed קס"א; logical §162): the great date-line question]

and all of them [the doubts] are thereby settled and resolved. This he wrote, of blessed memory; and he added that the beginning of each day's being called by its name lies at the [eastern edge], the place "like the east" — just as R' Ḥasan the dayan held, and R' Abraham bar Ḥiyya the astronomer, and R' Yitzchak bar Baruch. The Rav [Isaac Israeli], of blessed memory, wrote, and they concurred, sealed and concluded, that the place said to be "like the east" is specifically where the naming of each day *begins* — not any other place; and likewise the place "like the west" is specifically where the naming of each day is *completed*. His reasoning was that he held half the earth's sphere to be submerged in water — the view of Rabbeinu Tam and of nearly all the ancient sages — so that the last quarter of the sphere is the portion sunk beneath the water, and we need not concern ourselves with any inhabitants there nor with what they might call the day in question. On his premise, all the said perplexities are settled and nothing remains difficult.

But we have already shown above, in the First Section and again in the Third Section (as stated there), that the premise the ancients held — that half the earth's sphere is submerged in water — has already been overthrown. For all of them, whether of the children of Israel or of the nations, we found alike to have erred in this inadvertently. It has already become known to us — not by riddle but plainly — that [inhabited lands?] [?] encircle the whole globe of the world at every hour, literally: as the upper portion is to us, so is the lower portion beneath the soles of our feet — and this is the antipodal world (הקדם) mentioned above. This is especially so at the end of the fourth quarter of the earth's globe, where all the said doubts and perplexities are compounded, as explained — in a land of broad expanse, which is the land now called by the [name] of the New [World] [?], [an expanse?] like the ocean sea, close to the eastern edge, about [ ] degrees [numeral left blank in source]; and it is a great distance, wider than [ ] [?] the European part on which we wholly dwell. Accordingly, R' Isaac Israeli's answer is

thereby uprooted and has no foundation at all — notwithstanding that all the perplexities which he, of blessed memory, with the abundance of his sharpness and acumen, marshalled against the two sages [the *Kuzari* and the *Baal HaMaʾor*]: even so, the difficulty and the doubts remain in their place. In sum, in these four adjacent questions our hand has failed and our understanding fallen short; we have only gone astray in them, our lips [sealed] [?].

Know too, dear reader, that I laid these questions and the said perplexities before great masters of enigma and learned investigators who sit before our lord the Emperor Rudolf [Rudolf II], may his glory be exalted — men wise and profound, keen of mind, whose understanding is beyond searching out. To one of them who [pondered?] [?] the said questions I put them for some days; and they conceded to me [?] and did not [venture] to claim that their own lips held a correct and sufficient answer.

סימן קס"ב [printed; logical §163] — One who circles the earth's sphere, and sometimes loses one day of the days of the week and sometimes gains one day

One who travels around the whole earth's sphere from east to west loses one day of the days of the week; and one who circles from west to east gains one day of the days of the week. There is no difference whether he circles the whole globe of the world — were it possible — in four days, or in four hundred years, or in any other span of time: for practical benefit he will always, in the course of his circuit, gain one day of the days of the week. To make this comprehensible, and to give understanding of it even to young students, let us illustrate the matter briefly and lucidly, as though it were possible for a person to travel here around the whole globe of the world in four days; and we divide a round board into 24 [כ"ד] [parts / hours] [?].

Diagram. In the left column, a circle divided into four quadrants by a vertical and a horizontal diameter, representing the globe (the four "days" of the circumnavigation). The four division points are lettered:

- א (top): starting point (where the sun first rises on the traveler's horizon)
- ב (right) [?]: division point
- ג (bottom): division point (opposite א)
- ד (left) [?]: division point

The traveler's positions are read around the circle in the sequence ב → ג → ד → א.

Let this line that encircles the earth's sphere stand for the horizon-line of the day [?]. Suppose, by way of illustration, that Reuben sets out at dawn from point א on the sphere: from above, the sun rises upon his horizon, and by the coming of that first day he reaches evening at point ד of the sphere, and there he lodges. This is according to the rule laid down: [it is set] beneath his horizon from point ג. On the morrow, the second day, when the sphere has turned round for him from point א upon his horizon from one [day's] time to the next — and by [the reckoning of] Reuben's arrival [?] up to the second sunrise on day two — in truth, from the morning of day one from point א to the [morning] of day two at point ב there are [thirty?] [?] hours. For had Reuben remained standing in his place at point א, he would have had from the rising of the sun over his horizon to its setting a span of 12 [י"ב] hours; whereas because Reuben [traveled] up to point ב, the span of his sun's being over his horizon from point ד to its setting at point ג was [ ] [?] — so that the [length?] of his day was [thirty?] hours [?], and likewise his day's span in going from point א to point ב was about 28 [כ"ח] hours [?]. Correspondingly, so it would be for one who circles from point ג to point ד, and so on [?].

The reverse of this occurs when a person circles from the [west toward the east] [?]: [he will find] one day fewer [?]. Shimon sets out from his point, so that the sun comes to him on [the first day] [?], and it is [at point ב] toward the east; the sun meets him, and he circles until he comes to point ד, where he lodges; and on the morrow, day two, the sun is upon his horizon at point ג. Thus we see that he circled from one time to the next, from the morning of day one to the morning of day two, [and] he circles only 18 [י"ח] hours [?] — because his circuit [runs against] [?] the [sun's] circuit; for it [amounts to] only [ ] of a quarter of the sphere, which is an arc of [ ] [?]. On this reckoning Shimon circles [ ] from one time to the next, likewise about 28 [כ"ח] hours [?]; and so the law holds for each of them [?].

The sum of all this [comes] [?] to 72 [ע"ב] hours [?] — which for this circuit amounts, over all, to [ ] days [?], all of them [reckoned] from one time to the next for the whole globe of the world. In sum, then, [when Reuben, Shimon, and Levi stand at one place and time]: Reuben will go and circle toward the west, [Shimon toward the east], and Levi will not stir from his place; and the two circlers will return and meet [again] at point ג on [day?] [?]. For Levi, who stayed in his place, it will be day three [Tuesday] as [ordinary] [?]; for Reuben it will be the seventh day (Shabbos); and for Shimon it will be the fourth day of the week. And it is found that the total between Reuben and Shimon is **two days**.

[Rubric (small type, uncertain reading): possibly "בעזרת הבורא יתברך" ("with the help of the Creator, may He be blessed") or "באור הברת מלין" ("clarification of terms") [?]]

השער השביעי [The Seventh Section]

Here too will be explained the matters of the sun's course: how long the measure of its year is; how many spheres are found in its orb, and how many its circles; that the sun has four motions; where the mean and the true position of the sun in the zodiac lie; that it revolves an equal course in varying times; and other particulars besides.

סימן קס"ג [printed; logical §164] — Explanation of what is found in the sun, and likewise in the other planets: changes and many varying matters

Know that the ancient sages, in the abundance of their wisdom and the [profundity?] of their speculation and inquiry, filled [their books] with, and observed in, the sun — and likewise in the other six planets — many variations:

- (א) that all seven planets, though they complete their [mean] courses from west to east [ ] [?], [carry within them] [?] the [motion of the outer sphere?];
- (ב) that all seven planets sometimes rise and recede from the earth [from the center of the earth], and sometimes draw near it — the difference between their descent and their ascent amounting to [ ] thousands of parsaʾot;
- (ג) that the elevation of the planet itself, at its apogee, is not always in one place, for it too shifts from its place over the course of the years, in its own time;
- (ד) that equal motions are found in them in varying times, and varying motions [in equal times];
- (ה) that [in one place a planet appears to advance and in another to retreat — retrograde motion] [?];
- (ו) that sometimes they are seen [to stand still], their going ceasing, advancing neither forward nor back — to return afterward [to advance] [?];
- (ז) that it appears to us of a certain planet [the sun?] that one day it rises for us on the eastern horizon in the morning as [one hour] [?] [ ], more or less, and another day as [ ], [reaching?] the western horizon after sunset — all of

these the ancients called by [the name of "anomalies"] [?], and [each has its] [?] correct and settled [account].

[Note, below the section banner:] Above — as in the First [Section] — from these variations the ancient sages decreed that each of the seven planets must, by its nature, have a distinct ground [surface] or sphere of its own. As will now be explained to you in this Section, [we treat] all the said variations found in the sun, together with the other matters you require; but the said variations found in the other planets — their reasons and causes will be explained further on, in dedicated sections, God willing.

We begin with the configuration of the sun's sphere, though it is the fourth sphere by the nature of the planets; for it is nonetheless fitting to give it precedence, since knowing the courses of the other planets depends on the sun's course, and we cannot arrive at their motions and configuration unless we first know the sun's course and configuration. The sages already likened the sun, being in the fourth, middle sphere, to a king whose ministers circle about him, at whose command they journey and at whose command they encamp. And according to the view of the great investigator Tycho Brahe [טיכא בראהא], the center of the sun is the center about which the five planets [revolve] [Tychonic system].

סימן קס"ד [printed; logical §165] — The definition of the solar year, and likewise the measure of its time

In knowing the measure of the solar year we have a matter of great length [and difficulty], for by it we fix the intercalary day of our years [ ] [?].

Definition of the year: it is when the center of the sun now stands in its sphere opposite a known point [of the zodiac] — for example, opposite the head of the constellation Aries, or opposite some other first point — and revolves from there past all twelve constellations of the firmament, according to its own [proper] motion, and immediately returns a second time opposite the very same point from which it set out [?]. This is the correct definition of the year. And the measure of the span of the said [motion] — that is, the time [from the point back] to the point — [is what must be determined].

There is a dispute in this among the sages of the science of astronomy [?]; and it is already well known that a great difference exists between the reckoning of Shmuel [ריקנא"ט?] and the reckoning of R' Ada bar Ahava. For according to Shmuel the solar year is reckoned at 365 [שס"ה] days and a quarter, which are six

hours [beyond the 365]; while according to R' Ada bar Ahava it is reckoned at 365 [שס"ה] days, 5 [ה'] hours, 997 [תתקנ"ז] chalakim, and 48 [מ"ח] regaim [?]. [Over time?] this [difference has accumulated], so that in our day the difference between the time of *tekufat Shmuel* and the time of *tekufat R' Ada* is more than ten days. We have already expanded on this in our book *Maor HaKatan* [?], in its section on the [renewal / molad] [?], and here is not the place to elaborate.

As for the difference found in this reckoning — between the sages of Chazal and the sages of ancient days down to the present — the is too short to contain the writing of it. But know in general that the astronomers, the sages of ancient days and the sages of our forebears — among them Ptolemy of Egypt [תלמי מצרים], and among them the sages of Zion in our own city, the sages… …[with] instruments and their imperfection — they already labored much over it with speculations and inquiry [?], [that] the composite reckoning not be diminished, for it is a great, lofty, and deep reckoning. A deep, prepared foundation is needed to stand upon in order to learn the measure of the solar year: one must examine and be exact in all four motions found in the sun, as will be explained shortly, in Siman [= ק"ע 170?] [?]. For all this a great examination and a very deep reckoning are required; and required for it, too, are many years and days — not merely a few [ ], but even thousands of years. The ancient sages already investigated this matter, in their speculation, with great precision, and agreed that the measure of the year is 365 [שס"ה] days and a quarter, a little less [?] — [as?] the fourth-part day, and there enters [into it a small excess] [?], being exact in all the composite [reckoning], as in Ptolemy's [reckoning] [?].

The precise [measure of the year], according to Ptolemy [בטולמי], is 365 [שס"ה] days, 5 [ה'] hours, 49 [מ"ט] [dakim] [?]. And so I heard from the wondrous sage [likely Kepler] [?] — who was a student-colleague of Tycho Brahe [טיכא בראהא], and who likewise dwells [there], being reckoned foremost among the sages before our lord the Emperor Rudolf [רודולפוס], may his glory be exalted — that he agrees with the reckoning of Chazal, which is a little less than the reckoning of R' Ada, close to [ ] [?].

סימן קס"ה [printed; logical §166] — To know how much the sun moves in one day against the horizon of the zodiac

To know, according to the reckoning above, how many parts [or fractions] the sun revolves against the sphere of the zodiac in one day: know that, [given] [?] the measure of the year [ ]. This is an easy thing for those versed in the science of number, to calculate how much of the sphere's circuit falls to each day of all the

days of the year: one divides [?] the 360 [ש"ם] degrees of the sphere by the number and time [of the year] [?], and [the quotient] is the measure of each day of the year's days [?]. Our procedure follows the way of the masters of number, and we say: if 365 [שס"ה] days, 5 [ה'] [hours...] [ ] — we require, for the sphere's 360 [ש"ם] degrees, [to find] how much of the sphere reaches [in] one day; and you complete it duly, by the way of the masters of number, and there comes out for you a mean motion for one day of **59 [נ"ט] dakim, 8 [ח'] shniyim, 17 [י"ז] shlishiyim [?], 13 [י"ג] revi'iyim, [32 / 12] [ל"ב] [?]**.

[Cross-references, at the head :] This matter is [treated] in the book *Yesod Olam*, Essay 3, chapter [ ] [?], and in the book [*Neirot HaAretz*?] [?], Section 20, chapter [ ] [?].

סימן קס"ו [printed; logical §167] — That the length of the year is reckoned by the revolution of the sphere of the fixed constellations, and not by the [visible] figured constellations; and that the measure of the year stands at one measure

Ptolemy [בטולמיאוס], chief of the astronomers, wrote that the length of the measure [of the year] is reckoned by the revolution of the sphere of the fixed constellations [the sphere of the fixed stars] — [and not by] the [visible figures]. [ ] [?] in the [reckoning] as [the curvature?] of the upper sphere, the portion [ ] [?] (as in the Fifth Section, at Siman [110 = ק"י?] [?]). And so is the view and consensus of all the sages, ancient and later, whether of the children of Israel or of the nations: that the length of the year — the *tekufot* and the reckonings — is [measured by] the circuit of the sun's center [ ] back to [its] point, according to [ ] against the true, figured constellations, [as above] in the Fifth Section; their reckoning is not according to the [visible] sphere, for the [figured constellations], from point to point, as the circles of the figures, [give a value] exceeding a year [?].

For it has already been [set down] earlier, at the end of the Fifth Section, that according to Ptolemy the sphere of the [fixed] constellations revolves one degree in [a hundred] [?] years [precession of one degree per century]. Accordingly, when the sun's center goes out from a point — for instance, from the [resting place] of the head of Aries — and returns opposite it to the point [ ] in the sphere [ ] [?], [and] we reckon for it from the appearance of the point of the head of Aries [as a] star [?], [that is] not [truly a full return]: for it has already circled [ ] [?] as the [motion] of all the [zodiac], one part out of a hundred above one [degree], which is not [ ] [?]. In the Gemara it is written [ ] [?] [holding the tropical year] to

one measure, close [ ] [?] — as above. And the sage "Israeli" [R' Isaac Israeli] wrote [ ] [?] in his third essay, that [ ]. The later [astronomers] hastened, in this matter, against Ptolemy, and demonstrated and proved that [ ] [?] — [namely that the tropical year?] does not stand at [a single fixed] measure [?]: it [changes] by a very fine amount, imperceptible, not discernible for even a moment, [only] after some [hundreds] of years [?]. This is on account of one of the two causes — by reason of the [trembling and rocking motion — trepidation] [?], as we wrote at Siman [130 = ק"ל?] [?]; and the second, that the [point] [?], against the [constellations], in most of the [breaking?] [?], [likewise now shifts] from its place, as will [be explained] further on in this Section, at Siman [179 = ט"קע?] [?]. By reason of these two causes, the measure of the tropical year does not [strictly] stand at one single measure; and they are [ ] [?] — deep, intricate, and most wondrous matters.

But according to what we have received from the astronomers of our own time, they took no account of these two causes at all — for it has already been [shown] above, [as at Siman ק"ל?] [?], that the "trembling" (trepidation) motion is, in my view, not [among] [?] the motions of Ptolemy or of al-Battani [אלבתיאנו] at all. And also to note: the majority [treating] of the sun did not concern themselves with this matter, but rather their consensus, like that of the rest, [holds to] the tropical year.

סימן קס"ז [printed; logical §168] — That the sun's sphere has [several] spheres that revolve around the earth's sphere

Know that the sages [who follow], for the most part, those who speak of astronomy [ ] [?] — following Ptolemy [בטולמי] — [teach], in the greater part of what they say, [that the variations] found in the courses of the planets [are as] mentioned just above. [Ptolemy] investigated and set in order, with the abundance of his wisdom, the keenness of his intellect, and the reach of his inquiry, to find the cause — in which [ ] to establish, to understand and to settle what we [wrote] [?] — the wondrous and intricate [phenomena]. In any case, on this account [they hold] that each sphere among the spheres of the planets [is embedded] within another sphere that surrounds and covers it over its entire surface — over its convex side (its outer face) and over its concave side — in such a way that the thickness of each [portion] lies between two kinds of spheres, the one inner and the other outer. I shall now choose out for you their precise [account], with the sun's sphere, which is the one we are dealing with; and from it you will then understand the greater part of the surface [structure] of the paired spheres.

The inner sphere [of the sun's sphere]: the body of the sun is fixed in it like a nail in a wheel; and in this sphere its center is displaced [eccentric], for its center [does not coincide] with the earth [ ]. Likewise, the center of the zodiac sphere is not the center of this inner sun-sphere; only this inner sun-sphere is the one whose center is displaced. Therefore its center is equal neither to the earth's center nor above the zodiac, but is always closer to one of the extremities than to the other. As for **the upper sphere**, which is written [set] within the inner sphere [?], its center is the center of the earth, the same as the center of the zodiac itself; therefore it is at an equal distance, throughout the circuit of its concave face, from the earth's globe, and likewise, on its convex face, it is at an equal distance from the zodiac sphere. And the line that revolves upon its middle [runs] directly beneath the middle line [ ] literally beneath [ ] a star which is within it — this line, too, [tracks] directly beneath the middle line that is in the sphere [ ] [?].

The concentric sphere ("the resembling sphere," גלגל הדומה): because it resembles the circle of the zodiac itself in every respect — resembling it as regards its center [ ] [?]. [Its] center resembles the center of the zodiac, and it also resembles [the zodiac] as regards its [equal] division [?], being equal on every side throughout its circuit; and the earth's globe, like the zodiac sphere, is likewise equal throughout its circuit, [at] an equal distance from the concave face of the zodiac sphere.

סי' קס"ח [printed; logical §169] — Concerning the two spheres of the sun mentioned, described as three spheres

Know that the eccentric sphere of the sun is placed within [the belly of] the concentric ("resembling") sphere, evenly, like [ ] a case (tik) [?] for the eccentric sphere; and the concentric sphere in its entirety encloses the eccentric sphere from above and also from below (as above), in such a way that the surrounding sphere — which is the eccentric one [?] — divides and splits the thickness of the concentric sphere into two separate spheres. Although in truth both are one sphere, yet so that the matter may be better explained to students, we imagine them as though they were entirely separate; and it is accordingly called three spheres in the sun's sphere, all of which encompass the earth's globe on every side. But in truth all are as one [ ] [?] (as above) — only that for [our] part they are divided into three spheres, as you will see in the figure.

To make it clear to students, the [astronomers] separated [it] [ ] [?] and drew it upon a surface: the concentric ("resembling") sphere in its entirety, which is the outer sphere — the largest of all — and its [globe] [ ]; the inner [sphere], which is

the smallest of all — the sages made it [with] [ ] [?] surrounding [drawings]; and point א in the figure is [ ] [?] the center for both — [as regards] the concave face [?] of the great [sphere] and the concave face of the small one. And the great sphere, on its convex side, which is the [middle] line [ ] [?], its curvature [belongs] to the small [sphere] [?] — [ ], which, by its convexity, [ ] [?]…

שער ז — Seventh Section (on the Sun), continued

[Continuation of 168§ — סימן קס"ח as printed / logical §169]

with the sphere of Mars, which is near it above; and the small sphere touches, with its concave face — which lies opposite the inner face — the sphere of Venus [מגה, read נוגה [?]] near it [below [?] — the printed text reads "above" a second time, but the sense requires "below"]. The middle sphere is the eccentric [גלגל היוצא מרכז]; the sages call it [כרתו [?]], and so point **ב** in the figure is its center, both for its concave side and for its convex side. The same holds for the two circles, inner and outer, that together make up the "resembling sphere" [גלגל הדומה] — the ones drawn in black in the figure: point **ב** is likewise [their eccentric center on one face], while point **א** is the shared center for the concave faces of both the great and the small [black] spheres.

Diagram. In the right-hand column stands a figure of three (or four) concentric rings — the shell of the "resembling sphere" together with the white eccentric circle it encloses. At the common center are two labeled points, one set slightly above the other:

- **ב** (upper, at center): the center of the eccentric sphere [the displaced center].
- **א** (lower, at center): the center of the world / of the earth, shared by the concave faces of the great and small black spheres.

Caption beneath the figure (verbatim): " פה מרכז לשניהם, שניהם מקבילים את עגול הלבן היוצא מרכזו" — *"Here is the center for both; both of them enclose [run parallel to] the white eccentric circle, whose center is [displaced]."*

And these three spheres — each one is nested within the form of its neighbor: the great black sphere against its convexity, which is its outer circle, has its center at the point that is the center of the world [point **א**]; while against its concavity, its inner circle, [its center is point **ב**]. So too each of the black spheres has two centers, as depicted.

סימן קס"ט [§169 as printed / logical §170] — The form and structure of the fourth firmament, which is the sphere of the sun: how its thickness divides into three spheres

And you, O reader, I have already stirred you above in the First Section [to take an illustration from a single sphere]. So here too, know that the three spheres depicted in your diagrams are all complete spheres [כדורים שלימים] that surround the sphere of the earth on every side throughout the whole of its rotations.

סימן ק"ע [§170 as printed / logical §171] — That the middle [sphere], the white eccentric, and the sun itself, both touch the spheres of Mars [and Venus]

The white circle in the figure is the eccentric [היוצא מרכז]; [within it is depicted] the body of the sun, which is fixed inside its sphere. Likewise the other planets [כוכבי לכת] have three spheres of their own, just as the sun does. Therefore know: when the sun is at its apogee [גובה רומה] and Mars is at its perigee [שפל רומו], the two bodies — Mars and the sun — draw close and touch [כדבקים ונושקים] one another in the heavens; and likewise, when the sun is at its perigee and Venus [נוגה] is at its apogee, the two bodies — the sun and Venus — touch and kiss. This corresponds to that.

סימן קע"א [§171 as printed / logical §172] — Explanation of the sun's path-line [קו מסלול], which is the girdle of its revolution, always, and never departs from it

In the middle of the deferent [גלגל הנושא], whose sphere is depicted [in the figure], is drawn a single circular line whose center is [the center of] the sun; and it is engraved [חוקקת] and traced… and this is a line lying at the middle [of the thickness] from the figure, as [explained] above in §[106 — ק"ו [?]]. And this line is called the sun's path-line [מסלול החמה], since upon it the sun's center revolves, always beneath the ecliptic line [קו הקדרות], and this motion is called the mean motion [מהלך המצע], the even one, as will be explained. By it the sun completes its circuit against all twelve constellations in a full year, and by its revolution are settled all the seasons of the year — cold and heat, summer and winter. Recall all this, for you will need it later.

סימן קע"ב [§172 as printed / logical §173] — Five circular lines are found in the whole figure of the sun's sphere described above, and the eccentric center engraves a circular line about the center of the world

From the principles we have stated you will see that in the three spheres of the sun mentioned there are five circular lines, and they are these: • the outer circle of the sun's sphere — the largest; • the inner circle — the smallest; • [the two circles bounding] the eccentric sphere; and • the path-circle [עגול המסלול]. For as already explained, the center [of the black] spheres in the figure is point **א**, and the center of the eccentric sphere is point **ב**. Hence you will see [that] the body of the sun, by the [uppermost] sphere, revolves — its center [being] point **ב** — [and] makes a circle about the center of the world, which is [marked] in the figure at point **א**, engraving [a line] over its whole revolution.

סימן קע"ג [§173 as printed / logical §174] — How great are the dimensions of the thickness of the deferent [גלגל הנושא]

The thickness of the deferent that carries the sun is about [numeral: ?]… the center of the sun's deferent from its own center… twice; and the astronomers said that it is about the measure of the diameter [קוטר]… and it is one-fifth [חמזת — read חמישית [?]] plus [a fraction] of the measure of the diameter, as will be explained further on in the Eighth Section, in §[239] רל"ט. For we have already written above that the line encircling the sphere of the earth is [ה' אלפים וארבע 5,400 — מאות פרסה parsa [?]], and the diameter of the earth comes to [numeral: ?] by simple reckoning; and although [it was said to be] one thousand parsa [עשר מאות פרסה], and by [the fuller] reckoning [numeral: ?]… by strengthening and [reduction] the numbers come out to [numerals: ? — " תשעה ותת"ק ן" partly legible, ~900+ [?]] parsa. This is the measure of the thickness of the deferent, as [will be explained] further on in §[176/179 — קע"ק? [?]]; there it will be explained to you how far the sun's sphere is displaced from the center of the world. And see the *Ikkarim* [ספר העיקרים of R. Yosef Albo], Treatise IV, ch. [פ"ב? 2 — [?]]. [Numeric values on this page are largely clipped at the binding gutter and are flagged; see QA report.]

סימן קע"ד [§174 as printed / logical §175] — The reason why the three spheres of the sun were made to differ, each one distinct from its fellow

What the astronomers needed, in their conception, was to draw on paper three spheres… each of them differing [in thickness at its four quarters] from its

fellows; and it did not suffice them [to draw them] one within another, equal to one another, as was drawn above [in the figure], but [they had to draw them] one within another — because the center of the sun's sphere is eccentric… from the earth, as will be explained. Already the investigators [have shown, by demonstration], that there is no sphere [that leaves a void] within another sphere… and for this reason they were compelled to draw [it thus]; for the eccentric sphere that goes out [from center] between two other spheres — one above it and one below it — [must fill the gaps]: the sphere above it fills the void [רקות — read ריקות] with its convexity, and [the sphere] below fills [the void] with its concavity, so that no void remains; and no sphere enters within the hollow of its fellow. [Thus] the deferent [כדור הנושא] always keeps its center within the "resembling sphere" [גלגל הדומה], and the [resembling] sphere as a whole always keeps its center [at] Saturn [סארן — read the world-center [?]], its center coinciding [with the world-center].

סימן קע"ה [§175 as printed / logical §176] — Explanation of the saying of our Sages, of blessed memory, that the sun and moon are set in the second firmament [ברקיע השני]

Our Sages of blessed memory said in a Braita [ברייתא רבה זוטן [?] — source-name uncertain; cf. Chagigah 12b, where the second heaven, *rakia*, is the one "in which the sun, moon, stars and constellations are set"]: the sun and moon are set in the second firmament. They do not mean by this that both of them [are literally there]; nor do they mean that the "second firmament" is [reckoned] upon the sphere of Mercury [כוכב], which is second from above… the fine [sphere] which is second from above… — this distinction is [not] clear; rather it appears that they mean each one [is set] in the second [sphere] of its sphere-system… namely the deferent, the eccentric [היוצא מרכז]. The words of our Sages, of blessed memory, [are] not [to be taken] but as [pointing to] what is well known and visible to us, to our eyes.

סימן קע"ו [§176 as printed / logical §177] — That the two [black] spheres of the sun mentioned above each have two centers

Know that the "resembling sphere" [גלגל הדומה] as a whole, as depicted by the two black spheres in the figure, on account of the variation of its thickness in the world [is drawn] so that each of them has two centers. The great black sphere, against its convexity — which is its inner [read outer [?]] circle — its center is [as it were] the center of the world [in the figure, point **א**]; and against its concavity — which is its inner circle, [the line] which itself likewise borders and touches the

deferent — its center is displaced from the center of the world, and this is point **ב** in the figure. So too the small black sphere before it in the figure likewise has two centers, except that its arrangement is reversed: its line of convexity — which likewise borders and touches the deferent — has its center displaced from the center of the world; and its line of concavity is the reverse, [facing] toward the sphere of the earth, the center of the world. So that point **א** is the center for the inner circle of the small black sphere and also the center for the outer circle of the great black sphere; while point **ב** is the center for the outer circle of the small sphere and also for the inner circle of the great sphere.

סימן קע"ז [§177 as printed / logical §178] — That the middle sphere of the sun's sphere is absolutely eccentric, and by its revolution alone the length of the year is reckoned

Now the third sphere of the sun's sphere is the middle one, depicted in white, which is the deferent of the sun. It is absolutely eccentric with respect to its two circles, the convex and the concave, for both of them are [distinct] from the two spheres mentioned above and below it. For this reason it is self-evident, without need of elaboration, that point **ב** is the center both of its convexity and of its concavity; and likewise it is the center for the mechanism of the path-line. By the revolution of this middle sphere alone is the year reckoned, for it alone — and nothing else — carries the sun around the sphere of the world in its complete circuit of [365 — כשס"ה [?]] days. And [reckon] as a fourth [point] that it is not so with the "resembling sphere" as a whole: for both its outer and inner spheres [do not] make any motion at all, except that in some thousands of years they complete two kinds of motion: the first is the motion of the eighth sphere [גלגל השמיני], one degree in [70 — ע' [?]] years, as [explained] in §[214] ריי"ד and §[ק"ע 170]; and the second motion [shifts] the height of the apogee eastward, as will be explained shortly.

סימן קע"ח [§178 as printed / logical §179] — That the sun draws near to, and recedes from, the sphere and center of the earth

Know that the astronomers filled [their study] with contemplation and saw that the sun draws near to and recedes from the center of the earth from time to time by several thousand parsa. The cause of this is the eccentricity — the displacement of the center of the sun's sphere [also] above the center of the world [סארן — read the world-center [?]]; and this is the cause and reason that the deferent, keeping fixed the center of the sun, [carries it] little by little and distances it from the earth up to its apogee [גובה רומו], which is point **ג** in the

figure; and [there] it touches [א 'ולסס ה'? [?]] the sphere of Mars at point ו [as marked ו, ז, ח], at its farthest distance from the earth. This occurs at the summer solstice [תקופת תמוז], when the sun reaches the [head of the constellation… — continues on next page].

[Continuation of §178, סימן קע"ח] …to the beginning [לתחילת] of [the constellation Cancer], drawing it little by little until it reaches its low point [נקודה שפלה], which is point ד in the figure; and there it is also nearest to the sphere of Venus [נוגה] below it, and there it is at its closest to the earth — and this happens at the winter solstice [תקופת טבת], when the sun reaches the head of the constellation Capricorn [ראש מזל גדי]. And by the difference [ההבדל] between the far distance and the near — [some numeral of] years, according to the [structure] of the eccentric sphere — as already explained just above, that [the center of] the sphere that is eccentric is displaced [9,900 — ק"ת בתת אלף ט' [?]] parsa, and so forth — from this it is clear to you why the sun, in the near season, [is closer]: its circuit is by so much shorter to the center of the earth, and in the season of its distancing its circuit is by so much longer from the center of the earth. And the sage of Israel [חכם ישראל] wrote, in Treatise III, ch. 4 [מאמר ג' פ"ד — of *Yesod Olam*, Isaac Israeli [?]]: that the [Creator] made this so [רביעי — a fourth reason [?]] in order that the heat should not grow too strong when the sun [is near], nor the cold too fierce in the rainy [winter] days. But know that this reasoning holds only according to [the view of] the author [of *Yesod Olam* [?]], who found the [revolutions of the spheres] moving beneath the girdles of the constellations; whereas I have already written on this at length, more clearly, in the Third Section [שער שלישי], §[numeral: ?].

סימן קע"ט [§179 as printed / logical §180] — That the "resembling sphere" as a whole — that is, the two black spheres in the figure — according to the opinion of Ptolemy [בטולמיאוס], has a motion of its own, and it shifts the height of the apogee [רום גובה] that is in its place

Know that the "resembling sphere" as a whole — the two black spheres in the figure — according to the opinion of Ptolemy has no motion at all of its own, except what results by way of the motion of the uppermost sphere [גלגל העליון]. For in his time [Ptolemy's] the height of the sun's apogee was at point ג in the figure, [where] the head [apogee] of the sun was fixed as a nail within the frame [tik], in the [middle of the] constellation Gemini [מזל תאומים]; and it was reckoned that there was and would be the seat of its motion for all the days of the world. But the later astronomers found in this "resembling sphere" a heavy [slow] motion, whereby the two [black] spheres [displace] and turn the middle sphere —

the eccentric — necessarily eastward, with great slowness [וכמתון רב], in such a way that this heavy motion shifts most of the [apogee's] displacement eastward in our own times. And this is [the doctrine] that in [numeral: ?] years [כ' חלקים ופ"ם? [?]] the height of the sun stands against the ninth degree of the constellation Cancer [מזל סרטן]. Reckon for yourself the span from that time [Ptolemy's] until our own — some close to [1,430~ — אלף ותל"ק [?]] years — [in which] the height of the apogee has shifted close to [a fraction of] degrees; and by proportion, for every thirty thousand years [לשלשים אלף שנה] the height of the apogee would move through the constellation Capricorn [מזל גדי] at the winter solstice, and so forth. To this the sage [Isaac] Israeli [ישראלי] testifies: he wrote in Treatise III, ch. 4 [*Yesod Olam*], that the height of the sun shifts a degree in [בר"פ? — numeral uncertain [?]] [years], and accordingly the full circuit is not completed until after [כלסיסות"ת — numeral uncertain [?]] years. And Geraldi [?] [וגרח: [?]] — there is an error there [שיש שם טעות [?]] — ["ע"ג נסבוק"ה", garbled reference [?]] §[קי' י"ב — read ספר בכספר לנרות הארץ — chapter 12 [?]]; and in the book *Tzurat HaAretz* [צורת הארץ [?]], folio [ט'ן [?]], he wrote that the height of the sun's apogee, according to the opinion of Ptolemy, was [numeral: ?] degrees [and a fraction] from the constellation Gemini [מזל תאומים].

סימן ק"פ [§180 as printed / logical §181] — That the center of the eccentric sphere itself also shifts from its place

Know that when the height of the sun's apogee shifts from its place, likewise the center of the eccentric sphere itself also shifts from its [place]. For since the displacement of the whole sphere-body cannot [occur otherwise] — for if that were so, it [would collide] within the bounds of the sphere of Mars — rather it only [performs] the revolution of its center forever; and for this reason its center too shifts from its place, and it describes an arc about the center of the world, as [if it were] a circle of its revolution in respect of the diurnal aspect [הבחינה היומית], and so forth. [As for the] astronomers before us, [they said]: the center of the sun, by the diurnal motion, revolves [from] east [to west; and the sun, by the shifting of the sphere as a whole, moves from east to west], as [stated] above.

טיו' קפ"א [§181 as printed / logical §182] — That the sphere of the sun has four motions

From the principles we stated above it will become clear to you that four kinds of motion are found for the sun: (1) their fourth [read: the] motion [is] the [mean motion], from east to [west] each day, about [כ"ט וקכן פ' — numeral uncertain, ~0°59′ [?]] minutes approximately, [completing its circuit] in [365 — כשס"ה [?]]

days approximately; (2) the fourth, in a day [numeral: ?]...; [another] motion which is caused by the higher motion around the whole world each day, one degree in [about a third — כשלישית [?]], carrying with it all the fixed stars, together with the motion of the sphere [numeral: ?]...; the [third] motion, [which brings] the sun's apogee forward one degree in seventy years [70 — ע' [?]], as in §[ד"קע? [?]]; and the fourth motion — a heavy [slow] one — of the sun by the "resembling sphere," as explained above. And I have already chosen [to explain that] whoever wishes to arrive at the exact measure of the [length of the] year must [give it care]; and to be precise about all the [approaches of] the planets' motions requires study and reckoning... deep and profound, over many days and great toil, to reach [certainty]. Nevertheless I will [give] you enough to know the [approach of] the motions mentioned and found... just so, when [the star Mercury? כוכב כוכה [?]] and [Jupiter?] add... the fifth [motion] carrying [them] on the epicyclic sphere [גלגל ההקפה], as will be explained further on in the Fifth Section, §[240] ר"ם and §[[?] 54] נ"ד.

סימן קפ"ב [§182 as printed / logical §183] — Marking the mean place of the sun in its zodiac sign, and which is its true place from which to begin, and the difference between them, [in each of] the two places

Know that when the sun comes... [so that] we may have a [means] to recognize its place and the time of its revolution to more than [מע"פ — read מעל[?]] the minutes of the [numeral: ?] constellations through which the sun, whose center revolves always, passes beneath... the line of its [orbit], which is [reckoned] in the minutes of the line [and] thereby we know [its place]... we mark in [the figure of] the firmament its circuit; and [as for its] years, which we cannot recognize except by the mean motion of the sun as above — [there] it appears [numeral: ?], and so we cannot recognize the [true] course of the sun except by the minutes of the circle... in the way that each of the two [places] declares the other. And this: when [we are exact] in [computing] the sun's course beneath the girdle of the constellations... its course and its place in the firmament in two respects, [which] the astronomers named for it: the "mean course" [מהלך האמצעי] and the "second" [and the sphere... its true course and place in the constellations. And in order to explain [it] to the students... [continues on next page].

[Continuation of §182, סימן קפ"ב,] ...to the students, by the easier and simpler method [I saw fit] to open — [we set] two fixed circles: the great circle, whose center is point **א** [which is the center] of the constellations, whose center is the center of the earth; and the small circle, whose [center] is point **ב**, which is [as an illustration] of the eccentric sphere of the sun, as was explained just above in

§[178] קע"ח. And now [reckon] the matter accordingly, up to [the point where] the sun's center stands at point **ז** on the eccentric [המסלול]; and likewise [draw a line] from the center of the earth from point **ח** through the place of the sun's center to point **ו**.

Diagram. A circle (the zodiac / deferent) containing a small inner eccentric circle set near the center, with straight lines radiating from the small inner circle outward. Legible point-labels:

- **ב**: the center of the eccentric sphere (marked prominently to the right of the inner circle).
- **א**: the center of the world / earth (marked below **ב**).
- **ג** [?] and **ד** [?] and **ט** [?]: small labels clustered at the inner circle (uncertain).

[This figure has more than two uncertain labels]

Up to point **ח**, which is on the ecliptic of the constellations — and there will be a line [in the constellations]. Point **ח** is called the place [of the sun] in the constellations, that is, the true place; and the mean place… the true place… there is no [course of] the sun [along] one straight line, for it may [advance and lag]… so [that its] true place… [may differ] from its mean place by more or less. This [difference] arises [according to its position], from point **ח**… draw upon it a line to point **ח**… and [the sun] will be at point **ח**, the place… [right angles], properly and truly (neither [more] nor [less], and one is not to be over-precise) between the line of the diurnal aspect of the eccentric [היוצא] sphere… and the center of the earth toward the [places]… at the time it is at one line from the center… [when] the sun's center [is at] point **ז**… and if it be drawn at the time it is at another line [from] the center… up to the constellations at point **ט**, and this is the course [reckoned] by the minutes of the line **כ"ט** [numeral uncertain [?]] and so [too]…

Diagram. A large circle (the zodiac) crossed by diameters and radiating lines, with the sun's positions and the two centers marked around and within it. Legible point-labels:

- **ז** (top, at the head of the vertical radius): the apogee / head of the sun [רום החמה].
- **ת** (upper left, on the circle): [zodiacal reference point [?]].
- **ד** (upper right) and **ג** (right, just below **ד**): [zodiacal / apogee points [?]].
- **ח** (interior, upper): the true-place point on the ecliptic.

- **נ** [?] (center point): the central marker (reading uncertain — could be **מ**).
- **ט** (lower center, with a small hook) and a left-side cluster reading **ש/ט/פ** [?]: the perigee / low point [שפלה] and adjacent markers (uncertain).
- **ה** (bottom, with a right-angle marker): [the foot of the vertical radius].

[This figure has more than two uncertain labels]

And the small circles [in the figure] point to [ולעגולים הקטנים רמז] the sun's path-line [מסלול החמה], the eccentric, and its center; and point **ב** in the diagonal [ד'? — numeral uncertain [?]] is called the line of the mean [motion], passing over [between] the two centers, and… point **ז** [is] the head [apogee] of the sun, and point **ט** [is] its low point [perigee, שפלה]. And thus, when the sun's center reaches point **ז**, there will be no difference [חילוף] at all between the mean place of the sun and [its] true place; and the rule likewise [holds] when [the sun's center] reaches point **ט**, its low point.

And now know: when the sun, in its course, [passes] from the [apogee toward the] west, in every reckoning and computation, from the apogee down to the perigee, the true course precedes [יקדים] the mean course, and it is called [in the constellations…]; so that the true [course] is "more" [advanced] than the mean course from point **ז** [the apogee] down to the perigee, [by an arc] on the eccentric [numeral: ?] and [by] a mean [arc]… of the constellations. And the rule likewise [holds] for the [second half]: from the perigee up to [the apogee], the true course precedes the mean by [numeral: ?]; and thus, in the [other] places, from perigee up to [apogee] at point **ט**, [there is a lag]. As for the constellations [between] — and so forth — up to point **ח** [on the eccentric] the [true precedes the mean], and [the difference] extends [numeral: ?]; and the true course precedes the mean by an arc of [34 — ל"ד [?]], and so [too] the [second half], and thus at other places the [reckoning] shifts, up to a course of [24 — כ"ד [?]] on the eccentric, at point **ט** [[?] 60§ — נס'].

סימן קפ"ד

(Siman 184 as printed; logically §185)

That the sun completes an equal course in two different periods of time, or two different courses in two equal periods of time.

From all that has been said, it has become clear to us that the sun revolves against the sphere of the zodiac, in two equal periods of time, along two courses that are not equal — even though the cause driving the sun [שסבות החמה הממללת [?]] is always uniform, moving in one and the same manner, and there is no

doubt or hesitation about this among the sages: the sun never hastens and never lags in its motion from one occasion to the next, throughout all the days of the world. Nevertheless we find that the sun traverses, against the zodiac, two [unequal] distances [שני מרחקים [?]] in differing times: against some of the zodiacal signs it revolves swiftly, and against others it revolves slowly. This variation is caused by the center of the sun's sphere, which lies outside the center of the world; and our reckoning of distance — from the earth to the sun, and from the sun to the zodiac — is not measured from the center of the sun's own sphere, but from the center of the world. Therefore it appears to us, and we imagine, as if the sun itself moves through its sphere with this variation — which is in truth not so; rather the variation arises from the distance between the two centers.

For example: when we divide one of two circles into two equal parts, that smaller [circle] will divide the larger circle into two parts that are not equal, as you will see in the figure on the following page. [In that figure] the [outer] circle is the sphere of the zodiac, and its center is the point ס [?]; the inner circle, marked י-ט-ח-ו [?], is the sun's deferent, and its center is the point [ו/ט? — uncertain]. When a line כ-ט ו-ח [?] is drawn, as in the figure, it divides the zodiacal circle — from the head of Aries at the beginning of Libra — into two equal parts; yet it divides the deferent by way of it into two parts that are not equal. Hence, when the sun revolves —

— [when] the center of the sun [revolves] in the inner sphere [whose apogee is] toward the point of the sign [מזלו' — Aries?] up to Libra... [text partly garbled]...so that it does not revolve [across more than] the face of the zodiacal circle. In any case the sun in its sphere revolves in a time that is more than half of its circle, as is seen in the figure at the arc ט-ח-ו [?] — for the deferent is somewhat larger [along the arc] ט-ח-ו, and likewise the time of this revolution is more than half a year; therefore its motion along the arc [near] ט-ח-י-ד [?] is called the motion of [the ascending? מהלך הסימן]. And when it revolves from the region of Cancer... to the arc ט-ז-ו [?] — there too it revolves against complete zodiacal signs — yet in its sphere it revolves in this time less than half of its circle; and therefore, because the time of this revolution is less than half a year, [that motion] is called [מסלכ' בקצת ט"ז — uncertain]. So you have it: even though the sun revolves in its deferent with a course that is always uniform, still, against the circle of the zodiac it revolves with equal courses in unequal times.

סימן קפ"ה

(Siman 185 as printed; logically §186)

That the four seasons of the year, [reckoned] according to the true motion of the sun, are not equal to one another.

From the principles already mentioned it will become clear to you that, according to the true motion of the sun against the zodiac, the four seasons [תקופות] of the year are not equal to one another in measure, nor even close [to equal]. This is so when we divide the circle [of the zodiac] by two lines crossing crosswise — by way of a line [א-ט? ט-י?] and a line [ד-נ?] — into four parts, as issues [from the figure]. The lines divide the sun's deferent into four unequal parts. For the season of Nisan [spring], which lies at [the beginning] of Aries... in the fourth quadrant of the zodiacal circle, [runs] from the beginning of the circle of Aries to the end of Gemini.

[Figure follows — see below. The discussion of the four seasons continues in the text beneath the figure on the next page.]

Diagram. A large double-ring wheel occupying most of the page: an outer circle (the sphere of the zodiac, עיגול המזלות) enclosing an inner circle (the sun's deferent, מסלול), with two perpendicular diameters crossing at the center. Cardinal directions are lettered outside the rim; the zodiacal signs and a band of explanatory prose run around the rings. Most of the descriptive rim text is heavily garbled/abraded and could not be read with confidence.

- Center (intersection of the two diameters): **ה**
- Top of the vertical diameter: **ח**
- Right end of the horizontal diameter: **ז** [?] (apogee, רום החמה — per the model)
- Bottom, inner ring: **א** [?]
- Exterior, top: **צפון** ("North"; printed צפון פ/ק [?])
- Exterior, bottom: **דרום** ("South"; **printed** **זרום ק** — ז for ד, compositor error)
- Exterior, right: **מזרח** ("East")
- Exterior, left: **מערב** ("West")
- Rim band (upper arc, partly legible): **תאומים** (Gemini) · **סרטן** (Cancer) · [additional zodiac names and prose — largely illegible]
- Rim band (lower/left arc): **גדי** (Capricorn) [?] · [כ]קשה [?] · [remaining descriptive prose illegible/garbled]

[: more than two rim labels are illegible.]

[Beneath the figure, the discussion of Siman 185 continues:]

We divide, then, the four quadrants of the deferent [into their true lengths]; and thus, as they pass, the time of one revolution [through one quadrant] will run longer than the time in which [the sun] revolves through one of the [other] quadrants of the deferent. The sages labored [to establish] the measure of the time [of each]:

- **Tekufat Tammuz** (summer — from the beginning of Cancer to the end of Virgo): **[Hebrew: 52 = נ"ב½ days as printed; the arithmetic of the total (below) requires 92 = צ"ב½ days — compositor error, flagged].**
- **Tekufat Tishrei** (autumn — Libra to Sagittarius): **88⅛ days** [פ"ח יום ושמינית].
- **Tekufat Teves** (winter — Capricorn to Pisces): **90⅛ days** [צ' יום ושמינית] — smaller than all the rest.
- **Tekufat Nisan** (spring — Aries to Gemini): **[per the parallel list on the next page, 94½ days; see there].**

According to the reckoning [attributed to al-Farghani, סאלפרגני [Arabic: al-Farghānī]] [this quadrant is] 54 [?] days and [a fraction], approximately. [Text here is compositor-garbled; the day-counts are given more fully in Siman 187, below.] Do not let it trouble you that we reckoned all the seasons as always equal [in the older civil reckoning]; that [equal reckoning] is not [the truth], but only because the calculation of the seasons was established for us according to the mean motion, and not according to [the sun's] true place — as will be explained further on, in Siman [230 ?ר"ל?]. When we divide the [total] measure of the revolution [365¼ days] [equally], each quarter yields a tekufah of [91 days and a fraction; see Siman 187].

סימן קפ"ו

(Siman 186 as printed; logically §187)

[Continued from the foot of the figure page:]...hours and a half. And the ancients recorded [a rule?] for this [הקדמונים [?] נחמו וזכ'...] [garbled]...forever it will never [יוק? — illegible].

That, for the same reasons already mentioned, the measure of the natural days [too] varies.

We have already explained above that, in the revolution of the sphere of the zodiac, some [portions] rise along a long [arc] and some rise along a short [arc], as was mentioned [regarding right ascension]. In the same way there is a difference in the measure of the natural days [הימים הטבעיים], as was noted for

you — this matter [was treated] above, in Siman **קמ"א** [141? — printed קמ"א]. Know, therefore, from now on, that [besides] the cause of the difference in the rising-times of the zodiacal signs, there is yet another cause [that makes] the natural days perpetually vary — such that it cannot happen that in the whole year two days are found whose length is equal; and this [doubles the effect]. This is [also] the cause of the inclination of the sun's deferent from the [circle of the] zodiac: for since part of the [sun's] quadrant on the deferent adjacent [to a given point] varies [in relation to the arc beneath it], so too this rule will be found in each and every part [of the deferent], and in [the arc] beneath each and every sign — so that sometimes the sun appears as though it hurries more than its due course (the [motion] that is uniform for it, [namely] the same each day), by about 9 minutes 8 seconds [ט' דקין ח' שניות] approximately; and at another time it appears to tarry, less than its mean course. As will be shown in the [science of] astronomy [בתכונה], when the sun [traverses] the signs [where] its motion is slow — as in Siman [184] **קפ"ד** — then each day it moves with the smaller motion; and likewise, when it stands in the [six] signs of its larger motion, it too each day moves with its larger motion. And when the sun rises and falls [ascends and descends] toward the apogee and away from the apogee [נוכח רומה], it is [nearer/farther] each day against the zodiac — [more or less] than the mean course before us; and when it revolves from the point opposite the apogee up to the apogee, its course each day is added to the course of the [preceding day]... [some clauses garbled].

From all this it is seen that we do not find, in the whole year, two natural days equal in their length; rather this too [holds] doubly, and there will always be found more or less in the measure of each day compared with the measure of its fellow. But know that this difference between the natural days is a small, subtle, minute thing — so that the eye has almost no power to sense it directly; only the intellect testifies to us [of it].

סימן קפ"ז

(Siman 187 as printed; logically §188)

An explanation of the difference in time between the true tekufah and the mean tekufah.

The difference in time found between the two tekufot — the mean and the true — I have found [מצאתי [?]]... and a discrepancy of calculations [וקלקול חשבונות], for according to —

[The right-column text of the section closes here with the benediction: **"ברוך אלי וגואלי ומושיעי"** — "Blessed be my God, my Redeemer, and my Savior." The technical discussion, however, continues in the left column, whose sense follows directly from "for according to…":]

— what Rambam [Maimonides], of blessed memory, wrote in chapter 10 [כפ"י] of *Hilchot Kiddush HaChodesh*: the difference between them is about two days. And so wrote the Israeli [Isaac Israeli, in *Yesod Olam*], in the third treatise [מאמר ג'], chapter 6, which we mentioned — [regarding] the reckoning of the true tekufat Tishrei, [which comes] after [the mean by] two degrees, a little less [?]. [Likewise for the other tekufot:] the sun moves [at differing rates]... and so too the true tekufat Nisan is prior to [/ later than] the mean — as when the sun is at its apogee at [/near] the point ה [?] and its rising... And in the tekufot of Teves [and the rest], the variation between the mean and the true is recognizable, because [the sun's] places are as computed as we mentioned; and [this is treated] above [near Siman 146 ?קמ"ו?], [concerning] how the center of the deferent passes [relative to] the center of the eccentric.

This is the view of Rambam, of blessed memory, and of the Rav, the Israeli, in the places cited. And here I have found in one place, from the sage the Israeli, [something] that implies otherwise: for in the third treatise, chapter 3, he wrote — (that in [a source he calls Ptolemy, בטולמ"אוס [Ptolemy]]) — [that] one found, in the sphere whose center is the sun, [that] the fourth part of the zodiacal sphere, from the head of Aries to the end of Gemini, [is] **[Hebrew: 34 = ל"ד½ days as printed; the total below requires 94 = צ"ד½ days — compositor error, flagged]**, which is more than a quarter of a year; [and] from Libra to the end of Sagittarius, [it is 88⅛ days? — text garbled], less six hours [?] than a quarter of the year. According to this, the difference found between the two tekufot is [about] 9 days [and some] hours [ט' שעות].

In the books which I copied out [from the calculations I divided — from my two reckonings, up to a certain limit]:

- From **tekufat Nisan** to **tekufat Tammuz** (spring): **[34 = ל"ד½ days as printed; requires 94 = צ"ד½ — flagged]** [and a half].
- From **tekufat Tammuz** to **tekufat Tishrei** (summer): **[52 = נ"ב½ days as printed; requires 92 = צ"ב½ — flagged]** [and a half].
- From **tekufat Tishrei** to **tekufat Teves** (autumn): **88⅛ days** [פ"ח יום ושמינית].
- From **tekufat Teves** to **tekufat Nisan** (winter): **[90 = צ'⅛ days]** [and an eighth].

- **Sum of all: 365¼ days** [שס"ה יום ורביעי].

And since the time of one [mean] tekufah, according to the reckoning of the mean motion, is **[31 = ל"א days 6½ hours as printed; the mean quarter of 365¼ requires 91 = צ"א days 7½ hours — compositor error, flagged]**, as [given] near the end of Siman 185 — then, according to the reckoning of [Ptolemy, בטולמיאו"ס] and al-Farghani, [comparing the true seasons] with their [mean] words:

- **Tekufat Nisan**, [צ"ד =] 94½ days, exceeds the mean tekufah by **3 days, 4½ hours**.
- **Tekufat Tammuz**, which by [al-Farghani's] reckoning is [צ"ב =] 92½ days [printed נ"ב], exceeds the days of the mean tekufah by **1 [or 5?] day, 4½ hours**.
- **Tekufat Tishrei**, which by his reckoning is 88⅛ days, falls short of the days of the mean tekufah by **[2 = ב'/ג'? or 3] days, 4½ hours**.
- **Tekufat Teves**, which by his reckoning is 90⅛ days [נ' יום ושמינית], falls short of the mean by **1 day, 4½ hours**.

[Blessed be my God, my Redeemer, and my Savior,] **who has helped me complete the Seventh Section.** [שעזרני בסיום שער השביעי]

השער השמיני

The Eighth Section

Herein will be explained the structure of the sphere of the moon, together with an account of [its] inclined sphere and the time of the revolution of each of the seven planets [in its place]; the revolution and the motion of the moon in its mean and its true place; the definition of the molad [conjunction] and its causes; the many variations found in the moon throughout the days of the month; the mean and the true [reckoning] and the difference between them; [the moon's] nearness to and distance from the terrestrial globe, and a proof of the voluntary motion; the objectors on this [point], and the other topics and fundamental matters proper to it.

סימן קפ"ח

(Siman 188 as printed; logically §189)

An explanation of the sphere of the moon and the structure of its spheres.

Know that the early sages determined [an account] of the thickness of the sphere of the moon [as they did] for all the other spheres of the [seven] planets: each and every one of them is subdivided into [several? 58 = ?נ"ח? — uncertain] separate faces [/shells]... which encompass the terrestrial globe, of which three are [the principal ones]... And they determined it like the three spheres [/globes] of the sun's sphere; their properties too, and the laws and rules of the three spheres, are as mentioned above, in Siman [161] **קס"א** and Siman [169] **קס"ט**. But the lowest sphere [הכדור השפל] is as depicted below... [it lies within] the belly of the "resembling" [concentric] sphere [גלגל הדומה]; and [it is] a covering/shell [?] revolving...

and [as for] the inclination of the line of the zodiac [relative to] the straight [reference] line, as [explained] nearby — [being] the inclined manner in which no star [/planet] whatever is found [except upon it]... this inclined [orb], besides another orb ח' [?], they called the orb [of the node?]... or the orb of the [point] opposite [the apogee, הנוכח], for it bears and carries upon it the star of the moon [כוכב לבנה] — a star among the planets... and this is the [manner belonging to] the fourth sphere of the whole sphere of the moon. And the orb of the point-opposite-the-apogee is, according to the view of some [sages], [the orb] out of whose center [the motion] issues; and according to this we need to divide the thickness of the "resembling" sphere into two spheres, in order to fill out [its geometry] — by its convexity and its concavity, as [explained] above in Siman [174] **קע"ד**. [The "resembling" sphere] resembles [an empty] vessel [כוזא? — uncertain], and it does not suffice them that the inclined sphere [alone should exist] in the world... [there must also be] the deferent sphere [גלגל הנושא], since the "resembling" sphere and the inclined sphere are two [separate spheres]... [carrying] the head and tail of the dragon [ראש התלי וזנבו — the lunar nodes] from east to west around the [terrestrial] globe, as will be explained.

But here there are some sages who wrote that one cannot [dispense with]... in the sphere of the moon [with] the eccentric sphere [גלגל היוצא מרכזו], for it is impossible for us to derive [account for] all the motions of [the moon] without positing an eccentric sphere; and [this is part of] the intention of the view of the Israeli in the third treatise [מ"ג], chapter 8 [פ"ח], since in all the variations he relied [upon it]... as [mentioned] above at the head of the Seventh Section, in Siman [163] **קס"ג**, to settle the variations in the moon by means of its epicycle sphere [גלגל הקפה], as will be explained further on, in Siman [200] **ר'**. Therefore they said that the deferent sphere of the moon... [does not?] [have its] center [coincide] in general [with the world]; and that its center is the center of the zodiac itself. And according to [this]... the difference between the center of the

"resembling" sphere and [the deferent] — for they revolve about [it]... its center ח' [ר"ל? — uncertain]. According to this, too, we shall not need to divide the thickness of the "resembling" sphere into two spheres, for the [single] "resembling" sphere ח' [?] suffices us; since, according to this, the "resembling" sphere is uniform on all its sides and is not [subdivided] as [the sphere] of the sun is [subdivided]. For we have no need to fill out empty [volumes], as [we do] not [with] the sphere of the sun. According to this, too, the [deferent] sphere is, in its entirety, [contiguous/inclusive of] the [sphere] beneath it, along its paths [מסילותיו], in a manner that there is no difference at all between the "resembling" sphere and the deferent sphere — only that the deferent sphere [is inclined] from the "resembling" sphere toward the north and toward the south, as will be explained... And it appears to us that we are not compelled to assign to the "resembling" sphere any [perceptible thickness];

— it suffices us [to imagine] a thickness like the peel of an onion or an apple [בקליפת הבצל או תפוח], along the lines of what we explained above in Siman **ק"י** [110 regarding the fixed [stars] set in the [eighth] sphere. We have set it [so thin] only for the purpose of explanation and of depicting it to students — (so it seems to me) — while the thickness of the [empty] "vessel"-sphere is such that [the star? / the moon] issues from its center [as] one [does] not [assign] a thickness... as long as its thickness is like the length of the line [אלכם? — uncertain] and this [is] the [point] whose measure will be explained further on. According to what follows, you also have to know [about] the inclination of the deferent sphere from the [concentric] sphere... [garbled]...for it [the node?] always remains beneath the line of the [ecliptic/nodes, קו הקדרים], as [explained] above, at the head of the Fifth Section, in Siman [106] **ק"ו**, and [in] the Seventh Section, in Siman **קע"ח** [178.

סימן קפ"ט

(Siman 189 as printed; logically §190)

That the deferent sphere of the moon is inclined from the "resembling" [concentric] sphere toward the north side and toward the south side.

The early sages marveled, in their contemplation, that the bending sphere [גלגל הכופף? — the inclined/deferent sphere] of the moon — and likewise all the [other] spheres of the five [/seven] planets, each and every one of them — is inclined below and opposite the axis of the mean [motion], [away from] the line of the zodiac [/the ecliptic axis, קו הקדרים]: from one side its inclination is directed toward the north, and from the other side its inclination is directed toward the

south. Because of this they called it "the inclined sphere" [גלגל הנוטה]. And this matter of the inclination is [analogous]: it is like the inclination of the circle of the zodiac upon the equinoctial circle [עגול הישר], as [explained] above in Siman [35 ?ל"ה? — uncertain]; just so is the inclination of the deferent sphere from the "resembling" sphere — except that there is a difference between the two inclinations, [in details] which will be explained shortly, as [treated] above in Siman [?39] **ל"ט**. These two spheres — the "resembling" [concentric] one and the inclined [deferent] one — pass through the point-opposite [the apogee] upon the globe, and [both pass] over the center of the earth equally; they are of the length of [equal] diameters, and each turns the other into two equal parts.

Know that the inclination of the inclined orb from the orb concentric with the "resembling" [sphere] cannot properly be depicted on a [flat] surface... [but it can be rendered approximately] as in this figure:

Diagram. Two nearly-equal circles offset from each other (representing the "resembling"/concentric sphere and the inclined deferent sphere of the moon), with a small dot marking the common center at the middle. Cardinal directions are lettered at the exterior right and left.

- Inner right (on the horizontal): **א**
- Inner left (on the horizontal): **ב**
- Center: small dot (the shared center point)
- Exterior right: **מזרח** ("East")
- Exterior left: **מערב** ("West")

שער ח — Eighth Section (the Moon)

[סימן קפ"ט continued — printed §189 / logical §190]

(Continuation of §189, begun on the previous page; catchword there was לך.)

✻ But in truth the drawn figure of the sphere is not really like a circle, because the two spheres — the "resembling" (concentric) sphere and the inclined sphere — are, as it were, pictured as if each had its own separate center, whereas in reality this is not so: the two of them have only a single, shared center. For just as the ecliptic circle of the zodiac and the circle of the equator [lit. the "straight" line] are inclined one from the other yet share one center — as [explained] above in §36 and §39 [כב"ל כסי' ל"ו ול"ט] — so too the two circles, the resembling and the inclined, have a single center, something that cannot properly be represented in a drawing, since it is impossible to depict it upon a flat surface as it truly is. And it

has been explained already that, just as the sun is sometimes to the north of the inclined line, sometimes to its south, and sometimes on the equinoctial line itself, so too the moon; and likewise the five wandering stars [planets] are found sometimes to the south of the resembling sphere, sometimes to its north, and sometimes upon the [line of the] resembling sphere itself, [which is] the line of the nodes [קו הקדרות].

✻ And from all that has been said it becomes clear to you that, at the point of the inclination of the inclined sphere away from the resembling sphere, they meet and cut one another: half of the inclined sphere [lies] to the north side of the resembling sphere, and its other half [is set] to the south side. The two points of their meeting — the one toward the [east?] and the other toward the west — are the points called the Head of the Dragon and [its Tail]. The eastern node, from which the moon enters toward the north of the resembling sphere, is the point called the Head of the Dragon [ראש התנין]; and the western node, from which the moon enters toward the south of the resembling sphere, is [the point] called the Tail of the Dragon [זנב התנין]. When the moon travels upon one of these two points, it stands directly upon [the line of] the zodiac itself; and as it goes out from those two points, or [moves away] from them, it grows more distant from the resembling sphere and adds [to its distance] until the utmost limit of the inclined [sphere's] inclination from the resembling sphere. At that point [of maximum inclination] it departs from either of them by five degrees [ה' מעלות] of inclination, whether in its inclination to the north or in its inclination to the south. The diameter [or: axis], namely the line that goes out from the point of the Head of the Dragon through the center to [the Tail] and passes over its axis, is the Dragon itself, which is called in our tongue *aqalaton* [עקלתון — "the twisting serpent," cf. Yeshayahu 27:1] as stated in Yeshayahu, chapter 27. [Several numeric details in this passage are abraded: [?].]

✻ And it has been said above that this [maximum] distance [i.e. latitude] rises up degree by degree until it reaches [the pole/limit of] the uppermost sphere [?]; and it is explained just below that the two inclinations are reckoned by [the great circles] that pass over the poles of the zodiac. The half of the sphere that lies above compels [drives] the Dragon [?] more than the [lower] half beneath it, like [the] track [?]. The [details on the] paths [?] of the Head of the Dragon and its Tail will be explained to you shortly, and also further on in Section [16 / the Seventh(?)], in §[50 / ?]. [Numerals here uncertain: [?].]

וכתב [And R. Israeli wrote]: R. [Isaac] Israeli [author of *Yesod Olam*] wrote in Maamar [3?] [במאמר ג'?], chapter [8? / 5?], that there is a great difference between

the poles [lit. "lights"] of the resembling sphere and [likewise] between the poles of the inclined sphere: the poles of the resembling sphere are aligned [directly] opposite the poles of the zodiac in general, whereas this is not so for the poles of the [inclined] sphere, which are not aligned opposite the poles of the zodiac but are distant [from them], and this by five degrees [ה' מעלות] of the divisions of the sphere [?] and of [the line of] the nodes [הקדרות]. [Maamar/chapter numbers [?].]

סימן ק"צ — printed §190 (logical §191)

That three differences are found between the inclination of the sphere of the zodiac and the inclination of the inclined sphere.

We have already explained that, in the manner of the inclination of the zodiac-sphere from the [sphere of the] equator, so likewise is the matter of the inclination of the inclined sphere from the resembling sphere: one part [half] of the inclined [sphere] turns and inclines to the north side of the resembling sphere, and its second half turns and inclines to the south side of the resembling sphere. Likewise you should know that between the two inclinations three differences are found:

[First] — that the inclination in the zodiac is close to twenty-four degrees [כ"ד מעלות ≈ 24°], whereas here, in the moon, the inclination from the resembling sphere is at most five degrees [ה' מעלות = 5°], as will be explained shortly.

Second — [it concerns how] the [latitude of the] zodiacal inclination [is reckoned]: it is reckoned according to the manner [of the great circle] of the [solstitial?] colure, [and by] the other circles [drawn] and mentioned [as passing] over the face [surface] of the world [sphere], in order to know how great its distance is at each [point] from the equator, and the elevation [?] of the sphere. But the [amount of the] inclination of the inclined sphere from the [equator / zodiac] is not reckoned according to the manner [of the circles] of the solstitial colure [?], nor according to [circles through] the poles of the two [ends of] the world; rather it is reckoned by [the great circles] that pass over the poles of the zodiac, to know at every place and section how great is the distance of each arc of inclination from [the line of] the zodiac. This is the [latitude in] "breadth of the firmament" [רוחב הרקיע], as will be explained. **And the third difference** — that the two points of meeting of the resembling sphere with the inclined sphere are moving, and they shift westward within the zodiac, by the [motion of the] Dragon-sphere, by more than [several] parts each day, as will be explained shortly. [Interior numerals of the second/third difference are abraded: [?].]

סימן קצ"א — printed §191 (logical §192)

On the motions of the Head of the Dragon and its Tail.

The two points at which the resembling sphere [lit. "the deferent-manner"] meets the inclined sphere — which are called the Head of the Dragon and its Tail, as mentioned just above — have, both of these points, a special motion of their own [that carries them] from east to west, each day by more than three minutes [יתר משלשה דקים]. Their motion, too, comes from the [Dragon-]sphere, which revolves about the center of the world upon [the axis of] the poles of the zodiac and sweeps from east to west; and therefore the motion of the zodiac-sphere drives the spheres within it and turns them all in a general [westward] way. The two points [move] like [along] the Dragon [כתלי סוד התנין (?)], that is, by a retrograde motion of their own, sweeping against the whole zodiac in about [כ"מ?] years [full cycle uncertain: [?]], their motion being three minutes and eighteen seconds [שלשה דקים וי"ח שנית ≈ 3′ 18″] per day approximately [the seconds-value [?]; standard value ≈ 3′ 11″]. And the beginning of the reckoning [of their position] they set from the constellation Aries [מזל טלה]; and see [the] *Sefer Yesod Olam* [in Maamar (?), chapter (?)]. [Chapter reference [?].]

סימן קצ"ב — printed §192 (logical §193)

That the moon's position in the zodiac is reckoned both in the length of the firmament [longitude] and also in the breadth of the firmament [latitude].

We have already explained above, regarding all the stars, and likewise all the [circuits/revolutions] of the heavens, that when we speak of [and inquire into] their distances — how many degrees they are from east to west — this is called the "length of the world" [longitude], or the "great length." But "breadth" [latitude] is [the term] for [it] when we inquire about [and seek to know] the moon, or any other star, [to know] how far it is from the equator or from the pole [line] of the zodiac, whether toward the north or the south [side]; and all of this is called the "breadth of the firmament," or the "breadth of the world," [or] the [breadth] of the sphere. Now you must know that the moon's position in the zodiac [is reckoned] under two considerations. The first consideration is a reckoning proper [of longitude], of [its] position [and] the [amount of the] equation [?] [of longitude], whether by advance [קדימה] or by delay [איחור], all reckoned [along] the firmament, and the beginning of this is from a reckoning [starting] at the head of the zodiac. And under the [second] consideration there is no reckoning in the "breadth of the firmament," for the course of the sun has no latitude, since [the sun] does not stir nor depart from beneath the line of the

nodes [קו הקדרות], as [explained] above in §187 [סי' קפ"ז]. But under the second consideration — [that of latitude] — the moon's position is [also] reckoned [along] the firmament. And the matter of the moon's [descent/motion] in the breadth of the firmament, [which arises] because of the inclination of the inclined sphere from the resembling sphere: [the moon] runs its course and grows distant from the resembling sphere according to the degree of the departure of the [inclined] sphere from it — that is, the small [line/arc] between the center of the moon (which stands upon the [inclined sphere]) and the point opposite it on the resembling sphere; this [breadth] is called the "breadth of the firmament." And it has already [been noted] from this, above, that this distance [latitude] rises degree upon degree until it reaches [the limit of] the uppermost sphere [?]. And it is explained below that the two inclinations are reckoned by [the great circles] that pass over the poles of the zodiac. Therefore know that the distance of the moon's standing-point upon one of the lines [circles] of the zodiac, toward the [zodiac's pole], whether to the north side or to the south side, is what is called the "breadth of the firmament." And under both of these considerations there will be found, in each of them, a discrepancy [חילוף] [between] the moon's mean position in the zodiac and its true position, as will be explained further on in §[195?] [[?]]. [Several interior numerals in this section are abraded.]

סימן קצ"ג — printed §193 (logical §194)

How great is the amount of the inclination of the moon's deferent [bearing-sphere] from the resembling sphere.

We have already explained above that the moon's deferent [bearing-sphere] inclines and turns away from the resembling sphere on both its sides, up to a limit: for just as the sun is sometimes upon the equinoctial line [קו היושר] itself, sometimes to its north, and sometimes to its south, so too is the case with the moon, [which departs from the line up to five degrees]. This [inclination] is called by the philosophers [astronomers] "inclination" [declination]; and it is important to know the utmost limit of the moon's inclination beneath the line of the nodes [קו הקדרות], to test and verify [it, as done by] the earlier and later [astronomers]; and it will be explained to you [how great it is, namely five degrees]. [Some clauses here [?].]

[Observational demonstration:] By an instrument [כלי] one takes [a measurement] upon the position of the moon when it is at the utmost limit of its elevation, [sighting] it above our horizon [at some measured altitude]. [Worked example, computed for] the city of Prague [עיר פראג]: it has already been explained to us that our [equinoctial point] is elevated above our horizon by

about [a certain amount], and we shall not be exact about the fine detail here; and likewise we are distant from the equator by [52 ≈ נ"ב? — but the geometry below fits ~50°; value uncertain [?]] degrees. According to this, on the equinoctial [meridian] there rises above our southern horizon [a computed altitude]; and it has been explained that the utmost distance of the [ecliptic of the] zodiac from the equinoctial line is about twenty-four degrees [24° = כ"ד מעלות]. Therefore the utmost southern elevation of the [ecliptic] point for us is sixty-four degrees [64° = ס"ד מעלות], which [equals] the sun's greatest declination [added to the equator altitude]. And so, when we investigate, at the aforesaid time [the summer solstice, תקופת תמוז], by means of one of the instruments — a [sighting-]compass [כלי מחוגה] — the position of the moon when it is at the utmost limit of its elevation, [sighting] it above our horizon at sixty-nine degrees [69° = ס"ט מעלות], then its inclination — from the line beneath the line of the nodes, toward the north side, [reckoned] near to directly opposite the zenith of our heads — you will find [to be five degrees]. And so too you can investigate this at the time of the summer solstice [תקופת תמוז], and [again] at about half a [lunar] month [later?], when [the moon] is [at the utmost limit] of its elevation, that it [exceeds] what the sun [reaches] by more than [that amount] because of its inclination from the [resembling sphere]; and [thus the moon's maximum latitude comes to] five degrees each day [?] at the summer solstice; and so on. And the earlier [astronomers] were exact about the inclination of the [other] five wandering stars, each upon the surface of its own sphere; and this is [a matter for] a chapter in itself, [to know] how great is [each planet's latitude]. [Numerals [?] where noted; the values 24°, 64°, 69°, 5° and the latitude of Prague reconstructed from the Ptolemaic geometry — several individual glyphs abraded.]

סימן קצ"ד — printed §194 (logical §195)

Explanation of the matter of the epicycle sphere [גלגל הקפה] that belongs to the moon and to the other five wandering stars.

Know that the ancients, of blessed memory, in their study assigned to the moon — and likewise to the other five wandering stars — a further small sphere [כדור קטן], small in its magnitude, which does not [itself] surround the globe of the earth as the zodiac[-spheres] do; this sphere too, of itself, does not encompass the globe of the earth at all. And as to this sphere and its standing, know that, just as within the thickness of the epicycle sphere its center is set [and] above [it] the moon's epicycle is embedded within it, and the [deferent] carries it about the globe of the earth in general — as [explained] above in §164 [סי' קס"ד] — [so it is] within the [thickness/hollow] of the moon['s deferent]; and likewise for the

[epicycle-]spheres of the other wandering stars. [The epicycle] is called, in the Latin tongue, *ciclus* [ציקלוס — Latin *cyclus*, from Greek κύκλος, "circle"]. This epicycle sphere is embedded within the thickness and the bulk of the inclined sphere, like a "drawn stone" [aspiration-stone? loadstone?] embedded within a ring in every manner, and [in] the manner and form of the sun, which is embedded and fixed within the deferent [bearing-sphere], as [explained] above. There is, however, a great difference between them: for the body of the sun's globe is fixed within its deferent like a nail in a wagon, and it has, of itself, no motion at all in the world — only that the deferent carries it about the globe of the world. But this epicycle sphere is not at rest and still in its place, for it revolves continually in its place within the hollow, or thickness, of the deferent, as if it were a stone [rolling] within a ring; and the moon, and likewise each of the other five wandering stars, is embedded within [its epicycle] like [a nail in a wagon / a stone] set within its epicycle, and the epicycle sphere revolves the star in its place.

(This section continues in the right column of the next page.)

[The moon returns upon its epicycle in one period, and revolves about the earth by its deferent in another:] the [anomalistic] return of the star in its epicycle-period [is]: Saturn [שבתאי] in a year and thirteen days [378 ≈ שנה ויו"ג יום^{d}]; Jupiter [צדק] in a year and [thirteen? / thirty-four?] days [[?]]; the moon [הירח] in twenty-seven days and thirteen hours [27 ≈ כ"ז יום ויו"ג שעות^{d} 13^{h}], as will be explained further on. And under this [aspect], the epicycle sphere does not carry the globe [of the earth] around all the days of the world; rather it revolves forever in its own place, in one place, within the thickness of the deferent — and this is its southern [own?] motion. But [as for] the great [deferent] sphere in which the epicycle is embedded, [that great sphere] carries the epicycle, together with its star, in its course as mentioned, around the globe of the earth, in the [designated] period, [each] within about twenty-eight [days? — the passage lists deferent periods]: one of them [Saturn] in thirty years [30 = שנה ל' years], [and so forth,] whereas the moon [returns by its deferent] in twenty-seven days and eight hours [27 ≈ כ"ז יום ושמונה שעות^{d} 8^{h}], as will be explained to you further on at the end of Section [19? / — cross-reference number uncertain [?]]. And know that the diameter of the epicycle sphere is, according to the reckoning of the astronomers, about the [thickness] of the deferent [bearing-sphere]. And you should know that the matter of the epicycle sphere the ancients filled out [ascribed] specifically in the case of the wandering stars, which is not so for the star of the sun; for all the discrepancies found in [the sun] can all be settled by [the] "eccentric" sphere [גלגל יוצא מרכז], as was explained above in its place, in

the Seventh Section. But the [remaining] five stars — a star whose position [suffers] most of the discrepancies found [in it] — [require] more [than that]: what an eccentric produces is not sufficient for them, [and so] an "out-of-center" [device] is [added] to settle all the discrepancies that are found in them, as [more will be added] until the reader [continues on], [by] the mechanism of the epicycle sphere.

סימן קצ"ה — printed §195 (logical §196)

The figure of the epicycle sphere; and that its star, too, touches [is contiguous with] the sphere above it and the sphere below it.

I have seen fit to set before you the figure of the epicycle sphere, together with the figure of its sphere in which it is embedded, and [of] the [deferent] that carries it about the globe of the earth, together with its form and its track — for the epicycle is embedded, and its star is embedded within it, and it carries [the star] about, as [explained] above [[?]]. And [know that] the epicycle sphere is [itself] embedded within the thickness of the [inclined/bearing] sphere. When the center of the epicycle stands upon a [given] point [of the deferent], the star, [riding] upon the track [circumference] of the center of the epicycle sphere, will be there [at the corresponding point]; and it will be at that time between the utmost nearness [perigee] and the utmost distance [apogee], as will be [more fully] explained, together with the measure of the [near and far distances], and its [construction], [which] will be explained to you further on at the end of the Section, §[16 / 56 — [?]].

Diagram. A schematic of the moon's deferent-and-epicycle system. Several concentric heavy circles represent the carrying (deferent) sphere; along the inner edge of the outer ring runs the caption **מסלול גלגל הקפה** ("the track of the epicycle sphere"). Two or three smaller circles set within the ring represent the epicycle shown at successive positions (apogee near the top, perigee toward the lower right). A radius/diameter line is drawn from the central point outward. Point-letters are marked around and within the figure; the word **מזרח** ("East") stands at the lower-right, outside the outer ring.

- ט [tet] (top): epicycle position / node point
- ה [he] (upper-left, within a small circle): epicycle position
- ג [gimel] (left): point on the deferent [reading uncertain — could be ז/ד] [?]
- פ [pe] or ה (center): central point of the system [reading uncertain] [?]
- ז [zayin] (lower-right, within a small circle): epicycle / star position
- מזרח ("East"): orientation label at lower-right, outside the ring

- מסלול גלגל הקפה ("the track of the epicycle sphere"): caption along the inner ring

סימן קצ"ו — printed §196 (logical §197)

The moon's motion in its epicycle is the reverse of the motion of the other epicycles, and is called "the moon's motion in reverse" [מהלך הירח בהילוך הפוך].

Know that the epicycle sphere, as it revolves within the thickness of the moon's inclined sphere, [moves in] a motion whose direction is the reverse of the motion of the epicycle sphere of the five wandering stars. For [in the case] of each of the five: because [each of] the five revolves [its epicycle] to the side and in latitude, [carried] by [the deferent] sphere itself, according to its revolution — everything [going] from west to east, that is, when the star of the wandering stars [is at] the elevation [apogee] of its epicycle, then the epicycle sphere carries it eastward; from there [the star] descends westward until it [comes round], and it returns to the elevation of its [apogee]. But the moon's epicycle — its revolution is not so, for it revolves from east to west. An illustration of this: when the moon stands at the elevation [apogee] of its epicycle, at point ה [he] of its [epicyclic] circle, as above, and the center of its epicycle rests upon point ב [bet] — after five days [חמשה ימים], by the motion of the epicycle sphere, [the epicycle-center] has been carried by the deferent eastward and rests, at its center, upon point מ [mem] of the [deferent] circle, as above. And in these same days, the center of the moon has been carried from the top [apogee] of its epicycle westward, until it rests at point ז [zayin] of its epicycle. It is found, then, that when the moon [rides] the top [apogee] of its epicycle, [the epicycle] carries it westward, and from there it descends toward the east and returns to the north; and this motion is called "the moon's motion in reverse" [מהלך הירח בהילוכו], [arising] from the revolution of this epicycle sphere within the hollow of the deferent — that is, the [moon's] own [proper] revolution — until [the moon] returns [to complete its circuit].

[Its periods:] The [anomalistic] period, which comes out by a reckoning close to the "anomaly" [לנמנוס — Greek/Lat. *anomalia*], is twenty-[seven] days and thirteen hours [27 ≈ י"ג (?)כ"ז^{d} 13^{h}; the day-count glyph reads כ"ו/כ"ז — [?]], its daily motion being thirteen degrees and three minutes [י"ג מעלות ג' דקין ≈ 13° 3′] approximately. But the revolution [of the epicycle] about the globe of the world by means of the deferent [i.e. the sidereal period] is twenty-seven days, six hours, and forty-three minutes [27 ≈ כ"ז יום ו' שעות מ"ג דקין 27^{d} 6^{h} 43^{m}; the hour-glyph reads ו'/ז' — standard value ≈ 27^{d} 7^{h} 43^{m} — [?]], its daily motion being thirteen degrees [and some] minutes approximately [י"ג (מעלות) — [?]]. And the [synodic]

period between [one] conjunction [molad] and the [next] conjunction is twenty-nine days, twelve hours, and 793 parts [29 = כ"ט יום י"ב שעות תת"נג חלקים 12h 793 chalakim], the two [figures] being [apparently] contradictory [reckonings], yet they are one, for the whole comes out to one [and the same] reckoning, as will be explained to you further on in §204 [סי' ר"ד].

סימן קצ"ז — printed §197 (logical §198)

On the spheres of the moon and the orbs of the other wandering stars.

Know that in the heavens [where] the sun [gives light to the day?] [[?]], [the sun] as it were "leaps" and folds over from this orb [גליל] to that orb, [passing over the surface(s) of] seven [orbs? — number [?]], meeting [with them] each [year], as was explained above at the head of the Second Section, as in §123 [סי' קכ"ג — [?]]. So too the moon, which gives light to the night and [moves along?] leaping from orb to orb, and [passing over] about [87 ≈ פ"ז? — number uncertain [?]] orbs each month, twice[?]; and these are called "the orbs of the moon." These orbs are wider [more spread apart], each from the next, than the orbs of the sun; for [whereas] beneath the seven [orbs] the sphere revolves the moon in twenty-seven days and eight hours [27 ≈ כ"ז יום וח'/ה' שעות 8h — [?]]. And as the case is with this sphere, so is the case with each of the other five wandering stars, [each of] which performs [its share of] the [daily] southern [westward] motion upon the surface of its own particular orb, each day by [כ"ח? / a certain amount [?]]; and the width [spacing] of the orbs, too, is according to [the star's] period. [Thus] every single star, and [each] of the fixed [orb-]stars [כוכבי גלגל?], has this way with it. Because of this [manner of] motion of such a sphere, there is no latitude in it, and no one perceives in them any "leaping" from orb to orb — neither by this one[?] nor by that one — except when they [amount] to the seven[?]. [The heavens, though many, do not lack.] [This whole passage is numerically dense and heavily abraded; most interior figures are [?].]

הערה — Remark. At first glance it appears that one who wishes to be exact in the matters of the moon's orbs would find in them a reckoning greater [and more involved] — more complex and larger — than [the reckoning] of the sun's orbs. And this is [because] the [moon's motion is not] only [in longitude, whereas the sun moves] only in the length of the firmament [longitude], as [explained] above in §[160 / ?] [?]; but the moon travels [both] in the length of the firmament [longitude] and in the [breadth of the firmament — latitude], as we [have] explained. [Moreover, the moon's compounded motions are] larger [and more numerous] because of [[?]] that its [return] on its epicycle — [together with] the [motions] that the [orbs] produce by means of the revolution of the deferent —

[comes to some number of orbs]. In [the days? — פל"ך ימים [?]], twice in [each lunar] month, as above; and by its epicycle the moon makes twenty-two [= כ"ב 22 [?]] particular orbs, [tracing out] the width [surface] of its epicycle. And furthermore, the moon revolves in its epicycle sometimes from east to west, and sometimes from west to east, as [explained just above]; so that, since the discrepancies of the [various] spheres are [many], the exactitude [required] is great and abundant, and there are many rules and determinations required for this. And see further on in §207 [סי' ר"ז].

סימן קצ"ח — printed §198 (logical §199)

On the discrepancy found in the moon between its mean position in the zodiac and its true position.

We have already explained above, at the head of the Seventh Section, in §163 [סי' קסג"ג], and also in §182 [סי' קפ"ב], that there is no sign or better mark by which to know from it the measure of the time of the sun's course, according to its motion against the divisions of the zodiac [than the equation of center]. And just as this rule holds for the sun, so is the rule for the moon. The discrepancy found in the sun between its mean position and its true position in the zodiac — [existing] in the manner in which other discrepancies are found — is likewise found, so too, in the moon, [but] there more compounded, and [involving] more [rules] and determinations. And this is for two reasons. The first: that all the discrepancies found in the sun are caused by the eccentric sphere [גלגל היוצא מרכז], whereas [all] the discrepancies found in the moon are caused by the epicycle sphere [גלגל הקפה], as will be explained just below. And the second reason: that in the sun's course a discrepancy is found only in the length of the firmament [longitude], whereas in the moon its discrepancy is found [both] in the length [and the breadth] of the firmament [longitude and latitude].

And know [that] we come now to the explanation of the discrepancy between the moon's true position and its mean [position], and we shall come further to [treat] of the matters of longitude and latitude, in addition to what we explained above [in §138? — [?]]. Know as a general [rule] that the line that goes out from the center of the earth and passes through the center of the epicycle sphere, and the line that goes out from the center of the earth and passes through the center of the moon itself [up] to the firmament, [define the moon's positions]: [the second gives] the moon's true position in the breadth [/length] of the firmament; and the distance from the head of the zodiac to the [mean] position — as explained — is what is called the moon's mean position in the length of the firmament [mean longitude]; and likewise, the distance from the head of the zodiac to the true

position is what is called the moon's true position in the length of the firmament [true longitude]. And the distance of the moon's center from [the apogee] of its epicycle — [measured] from the point of the top [apogee] — is called the "[argument] of the moon" [מכ"ת הירח (?)], and in the Latin tongue it is called *[apogeum / perigeum — פיניגיאום, garbled]* [?]. An illustration of this: I say that the moon goes out at point [ב]...

Diagram. A schematic of the moon's deferent-and-epicycle system, illustrating the construction of the mean and true positions. Several concentric heavy circles form the deferent; the epicycle is drawn at three positions (top, center, and lower). A straight line runs from the central point ה outward toward the lower-right edge, representing the sight-line from the earth's center through the moon to the firmament (the true position), with a second line toward the epicycle-center (the mean position). The word **מערב** ("West") is written vertically along the left edge; the caption **מסלול גלגל הקפה** ("the track of the epicycle sphere") runs along the ring at the bottom.

- ה [he] (center): the center of the earth [origin of the sight-lines]
- ב [bet] (top, within a small circle): the epicycle at the apogee position (center of epicycle)
- ע [ayin] (upper-left): the epicycle-center position toward which the mean-position line is drawn
- מ [mem] (lower, within a small circle): a later position of the epicycle-center on the deferent
- ד [dalet] (right edge, on the line): the mean position of the moon on the firmament [reading uncertain] [?]
- ז [zayin] (lower-right, on the line): the moon's own position / true position [reading uncertain] [?]
- מערב ("West"): orientation label, vertical, left edge
- מסלול גלגל הקפה ("the track of the epicycle sphere"): caption along the ring

[Text continues around and below the figure:]...[the moon] which is [set] in its epicycle, and the center of the epicycle [rests] upon point ב [bet] of the track [deferent]; and after a known [number of] days, the center of the epicycle sphere will have moved [and] rests at point מ [mem] of the [deferent] circle, and in the time [of] those days the moon's center [has moved] from the top [apogee] of its epicycle, by its aforesaid motion, westward, until it rests upon point ז [zayin] of its epicycle; and [thus] the whole [figure of] the moon [describes] arc [[?]]. And now, likewise, from the center of the earth, from point ה [he] of the circle, [draw] two lines: the one [extending] to the center of the epicycle sphere, which is point

ע [ayin], and stretch it upward to the firmament, and bring it to point ד [dalet] — and this is called the moon's mean position in the length of the firmament [mean longitude]; and the second line is drawn [extended] to the center of the moon, which is point ז [zayin], and from it upward to the firmament, [going down/along] to point ל [lamed(?)] [?] — and this is called the moon's true position in the length of the firmament [true longitude]. And thus [we have] here the moon's true position. It is now good and useful to investigate the moon's mean position in the length of the firmament by means of an instrument, a quadrant [כלי רבע קשת], [in] §[159 — קנ"ט? / [?]].

(Section §198 continues on the following page.)

Siman 199 [קצ״ט] — The difference between the true molad and the mean molad

Know that, just as there is a difference and discrepancy in the moon between its true position [in longitude] and its mean position, so too there is a discrepancy and difference of this kind in the molad (conjunction). Ptolemy already reckoned, regarding the molad, that there is a true molad and there is a mean molad. The mean is the precise, computed one, and it is [defined by the moon's being] aligned opposite the sun; this is the moment of the sacred molad according to the truth. Yet by the exact reckoning, as the astronomers compute it, the intervals from one molad to the next are not equal on a single uniform basis, for one finds in them advance and delay [precedence and lag]. It is of this true motion that Chazal spoke [as I explained above]: sometimes it comes "at length" and sometimes "in brief," as will be explained further.

The mean molad is reckoned when the epicycle's center is aligned against the center of the sun; that is when it is called the molad. For the mean [molad] we do not insist on [pinning down] the moon's own actual place; we merely imagine, as it were, that the moon at that moment was at the apogee [rum ha-hakafah] or at the perigee [shifulo of its epicycle] — [so that] the mean and the true molad [coincide] at one and the same instant, as will be explained shortly. And by the approximate rule, the moon at that moment is neither exactly at the apogee nor at the perigee of its epicycle, in such a way that it is not aligned against the sun; hence it is not a molad in truth. In every case, only when the epicycle's center is [aligned] against the sun is a molad reckoned and is called the token of the molad. [It is called] "mean" because it is the mean [midpoint], the molad falling between two extremes — between the extreme of the moon's greatest distance and the extreme of its nearest approach along its course — as will be explained further on, in Siman 212 [ריב״]. And by this mean reckoning, the time between one molad

and the next comes out uniform forever, for it never lags and never hastens, never advances and never delays from one occasion to another; because whatever is deficient or in excess in this molad-reckoning relative to the true molad-reckoning is thereby [balanced], and it is made up or paid off in another month.

Siman 200 [ר׳] — Every variation found in the sun on account of the eccentric sphere is all found in the moon on account of the epicycle

After the matters of the epicycle and the matters of the two luminaries' motions — in their true and their mean positions — have been explained to you, you should know [per the figure of the sphere; see the diagram below]. [Just as the sun's variation arises] from [the position of] its center, so likewise in the moon, according to the structure of this epicycle. Now, in the sun it has already been made clear that sometimes no discrepancy at all is found between its mean position and its true position; sometimes the true position precedes the mean; and sometimes the reverse. And so [it is with the moon]. The variations [themselves are as follows]:

- **(א)** [When there is no discrepancy at all — when the moon's center in its epicycle stands at the apogee or perigee.] [?]
- **(ב)** Whenever the moon's center [in] its epicycle is at [the apogee], the true moon [is aligned with the mean] [?].
- **(ג)** And whenever the moon's center is [reversed], at [the perigee], as mentioned [?].
- **(ד)** When the moon's center [reaches] the line [drawn from] the center of the earth [through] the center of the epicycle [?].
- **(ה)** According as the moon's center is farther [eastward], up to the deferent-path of the [epicycle] center [?].
- **(ו)** When the moon is [farther] [?].

It is on account of this [pattern] that the ancient sages said the moon has no eccentric sphere [gilgal yotze merkaz]. But I inform you, so that you should know, that the moderns [ha-acharonim] investigated closely and found in the moon yet other matters and variations. I heard from a sage [i.e., learned report] that the sage **קפלירׄוס [Kepler]** [held] that for the moon['s sphere] [there is]… for the moon's sphere one eccentric sphere, and besides that — for the epicycle sphere — there is yet a second small sphere in its likeness. And now you have [the model with] two [nested] spheres of revolution [?].

Siman 201 [ר״א] — That the moon's spheres have six motions

From all the matters mentioned it is clarified to you that the moon's sphere has six motions, even [reckoning it] as [nested] uniformly with an inclined orb, whose motion follows its natural southern course from west to east:

1. The **daily [diurnal] compulsory motion**.
2. [A second daily / longitudinal motion] [?].
3. The **slow [heavy] motion** [of the nodes], [?] over a year.
4. The **motion of the epicycle**, as in Siman 151 [קנ״א].
5. [The motion connected with] the [Dragon's] head and tail, as in Siman 158 [קנ״ח].

And in addition to these, there is found for the moon's own body yet a **seventh** motion — intricate and complex — by which it traces an oval by itself, as will be explained in Siman 206 [ר״ו]. As for the number of circles that must be drawn for the moon's spheres, they properly are five standing circles, as are found in the sun's sphere — as was explained above in the Second Section, in Siman 27 [כ״ז] and Siman 152 [קנ״ב] — and in addition to these: the circle of the star-sphere, the circle of the epicycle, and the circle of the path of the moon's [own] body.

Siman 202 [ר״ב] — That the reckonings of the seasons and the conjunctions were established for us by Chazal according to the mean motion

Know that, according to what has already been explained — that the true motions of the two luminaries, the sun and the moon, [vary] — so too the times of the seasons [tekufot] and likewise the times of the conjunctions [moladot] are not uniform; rather there are in them advance and delay that differ in several respects: according to the differing [motions] in their courses and also in their latitudes, according to the changing position of the sun among the constellations, and according to the changing position of the moon among the constellations. Concerning such matters — and others weightier and more intricate still — was the great secret over which many labored in their calculations back when they used to sanctify [the new month] on the basis of eyewitness sighting; and they scrutinized and investigated these things in nature: [inquiring] whether the sighting [inclined] toward this side of the [zodiacal] wisdom or beyond it, to its north or to its south, how much it was inclined and how broad it was — as [the Sages] laid down in the second chapter of [Rosh Hashanah]. All these inquiries were according to the true reckoning, as Rambam wrote, of blessed memory, in

chapter 8 of Hilchot Kiddush HaChodesh, and R. [Isaac] Israeli in [Yesod Olam, maamar 1, chapter 18] [?].

These are weighty, deep, and hidden matters, requiring an exceedingly precise and profound calculation. Therefore, near the end of the era of the Sages of the Mishnah, when the [Roman] government decreed to slay [the Sanhedrin / abolish ordination], and it was no longer possible on account of the [decrees] to keep [a standing court] fixed in the Land of Israel, the Sages of Israel and Hillel the Nasi, his descendant, founded and instituted [the rule] to rely [on calculation] — for the intercalation of years and the fixing of the festivals — according to the [fixed] reckoning, and not [to be dependent] on witnesses nor on messengers. And this was in the year [c. 290 — reads ר״ץ / רי״ן; ?] after the destruction of the Temple, [namely] 4118 to Creation [ד׳ אלפים וקי״ח ליצירה; the final letter reads ח (=→ 118 4118 AM); the traditional date of the calendar's fixing is 4119 AM ≈ 358/359 CE — see QA]. The reckoning they founded was transmitted to us by Chazal as a foundation, based upon the mean course [of the moon], as Rambam wrote, of blessed memory, in his [statement on] Kiddush HaChodesh, and also elsewhere: that these two seasonal reckonings are all approximate, following the mean motion and not the true position. And so wrote the sage R. Israeli, in the order stated, according to the festivals, as they transmitted to us; and in exile we rely upon [this reckoning based] on the mean course, and we cannot do anything better than it. So too wrote the sage R. Israeli [in Yesod Olam], maamar 3, chapters 5 and 9, and in many places.

Siman 203 [ר״ג] — On the time of the moon's revolution in its sphere, the time of the revolution of its epicycle, and the time-measure of the moon's renewal

Know that when the moon stands, as above, inclined against a known point among the constellations — for instance against the head of Aries, or against another marked point — it revolves and circuits all twelve [reads תי״ב] constellations of the firmament according to its mean course, and returns to that very same point from which it set out. The time of this revolution, by the precise reckoning that I received from the wondrous astronomer **יאהניס קעפלירואוס [Johannes Kepler]**, is **27 days, 6 hours, 43 minutes, 6 seconds** — each day 13° 10′ 34″ 35‴ [thirds uncertain]. This is the revolution of the [moon's] own [sidereal] course toward the east, which is swifter, by about 13° [more]; and the [moon's] own body revolves, [returning] against all twelve constellations, in 27 days and known [fractions]. This is the revolution of the moon by means of the revolution-

sphere of its epicycle, at its place [i.e. the anomalistic return]: **27 days, 13 hours** — each day 13° 23″.

And the measure of the time of the moon's renewal [the lunation / synodic month], according to what he [Kepler] states by his precise reckoning, is **29 days, 12 hours, 44 minutes, 3 seconds, 11 thirds** — each day 12° 11′ 22″ [seconds uncertain] 11‴, all according to the mean course. This is close to the reckoning of our Sages, of blessed memory, [who set] the molad at **29 [days], 12 [hours], 793 [chalakim]** [כ״ט י״ב תשצ״ג]; for their reckoning differs from his only by the [fractional] part [i.e. seconds/thirds] — as we set out at length in our book, [Tzemach David / this work], in the small [treatise], in Siman 21 [כ״א] of the "Section of the New Moon," as is fitting.

Siman 204 [ר״ד] — The reason for the difference between the time of the moon's revolution in its sphere and the time-measure of the month

Because I have sought, for the benefit of the [students], since the time of the moon's revolution against all twelve [reads ל״ב] constellations of the firmament is only 27 days and [6 hours / a sixth], whereas between one molad and the next is 29 days, 12 hours [and 793 chalakim] — therefore, to explain and clarify it to students, let us reckon that the two luminaries conjoined at a molad aligned against the head of Aries. Suppose then that the moon separates from it [the sun] and revolves along its proper course; every sphere [completes its round] in 27 days and close to 8 hours, and it returns to the very same point where it had already renewed [itself] the previous month, as we posited, against the head of Aries. Behold, the moon does not [yet] meet the sun at the place from which it had separated, because in that time of 27 days and close to 8 hours the sun too has moved along its course, gently, close to 27°. On account of this the moon pursues it and does not overtake it until after 2 more days, and known hours and chalakim; and when you add those 2 days, hours, and chalakim to the 27 days and close to [8] hours, the total comes out to **29 [days], 12 [hours], 793 [chalakim]** [reads כ״ט י״ב תשצ״ג]. Thus it becomes clear to you that the moon does not renew itself in its sphere at the place where it had already renewed the previous month, but always, between each molad and molad, the moon circuits its whole sphere against all twelve constellations of the firmament, plus an additional [arc] of close to [27°]. By this manner the moon renews itself, each and every year, [across] all twelve constellations of the firmament. See above, in the Fifth Section, in Siman [130? reads קל״ה / קל״ם — ?].

Siman 205 [ר״ה] — That the moon revolves, in two equal times, two different motions

From the principles that we mentioned, it is clarified to you that the moon — and likewise every [wandering] star, since the [seven] wandering stars [move] in [their epicycles] — revolves, in its revolution around its epicycle, [in] two equal times two different motions, or [equivalently] two equal motions in two different times, on account of its sphere's [eccentricity], as we said in Siman 184 [קפ״ד]. But in the figure the discrepancy is found greater [in some places] than [in others], because [when] its slow motion is at the head of Cancer and its [proper motion] at [Aquarius], its true course being at the head of Capricorn and its [proper motion at Leo] [?]. The moon's discrepancy is in every single degree of the firmament — sometimes at a gentle pace and sometimes swift. For when the moon revolves above the [deferent] path, circling from point ד through [the points] to point א [per the figure mentioned above, in Siman 139, קקל״ט], it is delayed in its motion, since the motion of its epicycle is [opposite to / north of] the motion of the epicycle by means of the revolution-sphere. Then the star stands [as if drawn backward], and there is a lag [relative to] the firmament; and after it has revolved and come to point א, then the whole breadth of the epicycle is before the moon, [and the moon] is measured eastward. Therefore this motion is called the "slow motion" and also the "returning [retrograde] motion." And when the moon circuits below the path, revolving from point א in the figure, the matter is reversed [?] eastward, and it is called the "revolution of the diameter" [?], according to the length of the diameter of the epicycle.

[This holds for] every [wandering] star, since their course in their epicycles [runs] from west to east; when it is reversed, the [northward] motion is above the path, and [the star's position] is below it.

Siman 206 [ר״ו] — That in revolving around the sphere of the world, the moon makes for itself an oval — a path irregular and confused in illumination

Know that the path of the moon's own center, by reason of its rising and falling in its epicycle — [is not the same as the mean path]. The epicycle's center itself revolves upon the [mean] circle of the star-sphere, which alone is called the deferent [mesalul] of the star-sphere's center; and by its revolution the mean course of the moon is produced. But not so is the course of the moon's own center, [which follows] the true course, for sometimes the moon revolves above the [mean] path and sometimes below it, and sometimes upon the epicycle itself,

only slightly, each month, as will be explained. Before we come to the explanation of the matter, in order to explain it and make it agreeable to students by the easier route, we take the following: there is the time of the moon's revolution by means of the star-sphere around the world-globe, and the time of the moon's own revolution in its epicycle; and we do not [here] regard the [precise]... And the time of the moon's revolution in its epicycle, [together with] the time of its revolution around the world-globe — [see] the principle of Siman 205 [ר״ה]. And now hear the account of this path and how it comes to be:

[Note.] When the epicycle's center rests at [the head], at point **ג** in the figure, and the moon['s center] returns to point **ד**: after the first quarter of the month's days, the epicycle has already revolved its whole [circuit] by means of the moving sphere, through [the east], the fourth part of the deferent's [journey], until the epicycle's center rests at point **ט**; and in those [same] quarter[-days], the moon's [center] moves from the head of its epicycle through [the west], [three-]quarters of its epicycle, until it comes upon [the deferent] at its true place, at point [**ט**]. So it comes out that in the time the epicycle's center moves from point **ג** to point **ט**, in that very same time the moon moves from point **ו** to point **ז**, and in those days the moon sweeps, within the surface of the inclined sphere, an arc of [76°, ע״ו — ?]. In the second quarter of the month's days the epicycle revolves its whole [circuit] until its center rests at point **ח**; and in those days the moon's revolution in its epicycle [continues] until its center rests at point **מ**, at its perigee [shifulo], and the moon sweeps in those days an arc of [75°, ע״ה — ?]. In the third quarter of the month's days the [epicycle] revolves until its center rests at point [**ט**]; and in those days the moon's revolution [continues] until its center comes upon the deferent-path at its extreme, at point **ג**, with the moon's own center at point **ד**, and the moon sweeps in those days an arc of [40°, מ׳ — ?].

Behold, then, that the moon's whole path is an oval [reads עגול... ?]; and it is clarified to you that the moon does not move, by this reckoning, upon the deferent-circle, but only as in every month... sometimes, as I stated in the introduction, near point [**ט**] and [**ד**]. It is further clarified from this that the path of the moon's body — which is an oval [ellipse] — is smaller than the circle of the epicycle; also that its nearness and its farness are not uniform with respect to the epicycle-circle, so that we need to assign it a distinct center of its own — and in its middle [?] its center is point **א** in the figure, which is distant and above the center of the star-sphere by about the length of the radius of the epicycle. After all these things [the matter will be expanded] [?].

Diagram. A large semicircle drawn across the foot of the folio, spanning both columns, representing the moon's inclined/deferent sphere. Its horizontal diameter forms the base, labeled at its two ends **מזרח** ("East," at the left end) and **מערב** ("West," at the right end); the apex of the semicircle at top center is labeled **ט**. From the mid-point of the base (the earth's center) straight radii/sight-lines run outward to the epicycles drawn on the arc. Two small epicycle-circles are shown on the deferent, each crossed by a diameter:

- Upper epicycle (nearer the apex ט, right of center): **ה** (top), **ו** (center), **ז** (lower).
- Lower-left epicycle: **א** (upper, on/near the deferent), **ד** (center), with **מ** marked on the deferent at its outer (west) side; interior/rim labels **ב**, **ג**, and **ל/פ** are present but their exact placement is uncertain [?].

שער ח — The Eighth Section (The Moon)

[Continuation of סימן ר"ו — printed §206 / logically §207] — the moon's own oval body-path

It will also become clear to you from the figure that when the center of the epicycle reaches point ג of the figure, the center of the epicycle and the center of the moon stand directly one opposite the other [aligned]. The same holds when its center rests at point ח [?] of the figure. And when the center of the epicycle is at point ש of the figure, the epicycle-center has a precedence over the moon, measured along the length of the firmament, by [an amount equal to] half the diameter of the epicycle sphere. Conversely, when the center of the epicycle is at point ח [?] of the figure, the moon has a precedence over the epicycle-center, along the length of the firmament, by half the diameter of the epicycle. [The two point-letters ח here appear to conflict; at least one is a misreading or a compositor error — flagged.]

Diagram. A large deferent circle centered on point ב (with point ה adjacent at the center), carrying four small epicycle circles set at the top, right, left, and bottom, together with a dashed eccentric circle offset upward. It illustrates the moon's deferent-and-epicycle model with its displaced (oval) path.

- ב (center of the deferent): center of the star-sphere
- ה (beside ב, center): the moon's own path-center
- ד (apex of the top epicycle): topmost point
- ג, ש (top epicycle, flanking the apex): epicycle points [positions uncertain]
- פ (top epicycle, far left): epicycle point [?]

- ק (right epicycle), beside the margin label מזרח ["East"]
- א (left, on the horizontal diameter), with מ to its left [possibly an abbreviation of מערב, "West," or a left-epicycle point — uncertain]
- ס, ח (bottom epicycle): epicycle points [positions uncertain]

סימן ר"ז — Siman 207 *(printed ר"ז / logically §208)*

That the body of the moon is composed of many distinct circles and orbits, greatly intertwined and confused, most of which are beyond number.

You should know that everything set out above is [to be taken] "as if": it is as though the moon were [carried] by the deferent sphere, and the moon's revolution by its epicycle sphere were equal in measure [to it]. Were the matter truly so, the moon would return, in the fullness of our world-cycle [?], at every new-moon, to the apogee of the epicycle upon its own body[?], and likewise [return] to the perigee, and to the mid-point of the epicycle's path — and there would be no difference between one month and the next for all time. But in truth it is not so, for the discrepancies found between the time of the moon's revolution upon its epicycle sphere and the time of its revolution about the world-globe are what cause the moon's body [to stand] at the apogee of the epicycle sometimes at the new-moon and sometimes at [other phases] — and so it is for every day and every portion of the month.

You should further know, from what was explained above, that the moon's body has, in its revolving, circles, orbits, and many centers — most of which are beyond number — for according to what [will be shown]...

as we already explained above, that when the body of the moon rests directly opposite [?] its apogee at point ז [?], its center [lies] above [or below] the center of the deferent [?] sphere by [an amount equal to] half the diameter of the epicycle sphere; likewise, when the body of the moon rests opposite [?] at point ע"ג [?], its center [lies] below the center of the carrying [deferent] sphere, again by half the diameter of the epicycle sphere, and it will be at point ת"ב [?] of the figure.

And so its rule holds for every part of the deferent sphere, in every single place where the body of the moon happens to rest: it forms a [displaced] circle and an orbit of its own[?], as we mentioned. Not only [does this happen] at every new-moon and month of the year, but truly at every [phase] — a fact that was not [recognized] until after many years and centuries. All the days of the [month] I call this an "intertwined orbit" [מסלול מבולבל]. From all this it will be shown to you that these matters are intricate, entangled, and confused — its circles and

orbits — as we already explained above in Siman קל"[?] [a back-reference to an earlier siman, number uncertain].

Diagram. A large circle whose outer ring is divided into twelve segments, each marked with a Hebrew letter (the zodiacal signs, running א, ב, ג, ד, ה, ו, ז, ח, ט … around the ring). Within it sits an inner deferent circle carrying four epicycles (top, right, left, bottom) and a dashed eccentric. The top epicycle bears the numerals [15, 16, 17] יז, טז, טו and a letter; the other epicycles carry further letter/numeral labels. It depicts the moon's mean place on the zodiac at successive positions, each with its epicycle.

- Outer ring: א, ב, ג, ד, ה, ו, ז, ח, ט … (the twelve signs, numbered by letter)
- Top epicycle: [15, 16, 17] יז, טז, טו, with a point letter [?]
- Right, left, and bottom epicycles: additional letter labels [several uncertain]

סימן ר"ח — Siman 208 *(printed ר"ח / logically §209)*

The difference between the line that issues from the center of the earth and the line that issues from the pupil of the observing eye standing upon the surface of the earth-sphere. *(That is, parallax.)*

The difference. There is a [considerable] difference between the line that issues from the center of the earth, passing through the center of the moon and extending onward to the firmament — reaching it at [a certain point] among the degrees [?] — and the line of sight that issues from the pupil of the eye of the observer standing upon the surface of the earth, which also passes through the center of the moon and extends and reaches the firmament [at a different point]; for [the observed place] is what [the astronomers] call a [displaced] elevation [?]. In the foreign tongue this is called *Parallaxis* (פרולקסוס) [Latin/Greek *parallaxis*, "parallax"]. And I wish to make this clear to the students visually, by means of the quarter [-circle] figure [drawn below] [text partly garbled — "קלג / עגול המולד" uncertain].

Diagram. A quarter-circle (90° sector). Its right-angle vertex, at the lower right, is point ז — the center of the earth; from it one radius rises vertically to point א (top), and another runs horizontally to point ג (lower left); the arc sweeps from א to ג. Lines drawn from the vertex through the moon's center cut the arc; the observer's offset position lies along the lower edge. It demonstrates how a body seen from the earth's surface appears lower (nearer the horizon) than it would from the earth's center.

- ז (right-angle vertex, lower right): center of the earth

- א (top): firmament / zenith direction
- ג (lower left): terminus of the horizontal radius
- ב, ח (along the vertical edge / arc): firmament points reached by the earth-center line
- פ (lower edge, offset from ז): position of the observing eye on the earth's surface
- ד, ס (lower edge): further points
- ה (interior): center of the moon
- ו, יה (interior intersections): construction points
- ל (interior): the moon's apparent (lowered) place

** The description reads: let a quarter-circle be drawn like that of the deferent sphere; and a right-angled quadrant in the likeness of the earth [is drawn], marked [?]. Let point ז be the center of the earth, and point פ the place of the observing eye that stands upon the surface of the earth; and suppose that at point ה, partway along [the line], the center of the moon is set. Now we draw a line from ז — from the center of the earth — through the moon and onward to [its terminus], and this is the line [reaching point ב], descending from the center of the earth toward point ב [?] on the firmament — [giving] the moon's true place among the degrees. And the line of sight [קו ההבטה], line פ, from the eye of the observer standing upon the surface of the earth, descends as though the moon rested at point ל — [a place] lower than point ב and nearer the horizon by the arc [of parallax]. As a general rule, know that the parallax of the moon [שנוי מראה, "change of appearance"] is always greater the lower and nearer the moon is to the line of the horizon [measured] from its [true] place; and the nearer it is to the horizon, the greater grows the arc of its parallax, while the higher it is [above] the horizon, the smaller the arc of its parallax.

**...[the correction] diminishes as the altitude of the moon increases, until, at a place 90 degrees above the horizon, this difference is entirely nullified. All of these matters [the astronomers] compute precisely [only] for the two latitudes of the moon [?], because the moon is near to the earth-globe. Just so, the half-diameter of the earth bears a perceptible ratio and measure with respect to the observation [of the moon], [and] with respect to the line issuing from the center of the earth... [the correction is] a small matter, and [reckoned] precisely and by itself alone. Even one who says [that it applies] also to [some fifty?] [must] be precise about the two latitudes; and this is a small thing, [applying] on its own. [Line partly garbled — figures uncertain.]

סימן ר"ט — Siman 209 *(printed ר"ט / logically §210)*

The definition of the molad (conjunction), its time, and the cause of the many variations found in the moon throughout the days of the month.

The author says: I saw fit to explain in this place, for the students, the definition of the molad — its nature, its time, and the cause of its waxing and waning throughout all the days of the month; and why it always appears at the beginning of the new-moon, at the start of the night, in the south-western quarter [of the sky], while at the [end?] of the [month] it appears at the end of the night in the south-eastern quarter; and why the moon's inner face and its horns turn sometimes toward the east and sometimes toward the west; and why, from the beginning of the month, day by day until the day of [full illumination?], the moon [rises later?] and travels on until the middle of the month, and from there onward, day by day, its magnitude [of light?] wanes until the end of the month; and why, from the beginning of the month until mid-month, the moon rises above the horizon [later?] each successive night, and [its illuminated portion grows], while from mid-month on it rises earlier [?] each night; and why, at the beginning of the month and likewise near its end, the moon is seen [as a crescent] with horns, whereas it is not so seen on the other days of the month.

And the term [molad] requires that one know that the molad is the moment when the moon, as it revolves upon its sphere, draws near and comes directly opposite the sun — its center standing aligned beneath the center of the sun — which is [the end of the old month that has passed and the beginning of the new month]. At that time the moon [hides itself] entirely from our sight, as [on the day of conjunction], and about [a day?] after the molad, as will be explained [below].

And now, how, and the reasons — the cause of all the varied appearances of the [stars / the moon]: the body of the moon is a round globe, [mixed?], somewhat resembling in its ruddiness [the color of polished] bronze — for it is [suited] to the eclipse[?]... [The moon] is [clear] as pure sapphire [ספיר] and revolves [like Venus?] in the heavens; in itself it has no light at all... as will be explained [in Siman ר"ך?, a cross-reference — number uncertain]; and although the moon gives us light, that light is not from itself, but comes about through the casting and reflection of the sun's [rays] upon it: what it receives from the sun it [reflects] and radiates outward. It is like the appearance of a cast [mirror] of iron or polished bronze, which, when you set it opposite the sun, [catches the light] and shines and casts a radiance from itself. And you should know...

And now you should further know [that the moon's] globe [?] sometimes appears to the inhabitants of the world as half, and sometimes full [and dark, giving no light]; and this is because [only half] of the moon [faces] the sun[?]; and thus, day by day, it shows its light to the inhabitants of the world according to its distance from the sun: as it draws near to the sun, its shown light lessens and diminishes; so that from the beginning of the month its light goes on increasing for the inhabitants of the world up to mid-month, and from there onward its light wanes and diminishes until the end of the month, as will be further explained.

And so that these matters may be clear to the students, I saw fit to draw [a figure] to show [them] to the eye, this being its meaning: the upper circle is the likeness of the form of the body of the **sun** [שמש], and the great circle beneath it, which they [mentioned], is the likeness of the moon's orbit; and point פ at its center is a token for the pupil of the eye of the observer [who looks] from the surface of the earth and observes the moon; and its position is marked upon the line of the orbit as noted. We begin with the moon [in its first station], which is the place at the moment of the molad, when the moon has drawn into the utmost proximity opposite [the sun] beneath it, where the two centers stand aligned one beneath the other, as above.

Diagram. A woodcut of the lunar phases. At the top is a disk labeled **שמש** ["Sun"], from which straight rays fan downward. Around a large circle (the moon's orbit) are arranged some ten small moon-disks, each shown half-black (the dark side) and half-white (the sunlit side), their bright halves turned toward the sun's rays; at the lower center sits point **פ**, the observer's eye. It illustrates how the sunlit half of the moon is turned progressively toward and away from the earth-bound observer through the phases, from conjunction (molad) to full moon.

- שמש (top disk): the Sun
- פ (center of the great circle): the pupil of the observing eye, on the surface of the earth
- the ring of half-lit disks: the moon at successive positions of its monthly cycle

** Then the sun pours its rays upon the moon, and there is illumined the entire half-surface of the moon that faces upward [toward the sun]; while the half-surface of the moon that faces downward [toward us] the sun cannot reach, so it remains in its darkness and gives no light to the children of the world at all. The reverse occurs when the moon has drawn away from the sun by [half a month]: for then the sun is [in the west] and the moon in the east, with the earth between them; and then, since the centers of the sun and moon are aligned [in opposition],

[the sun] pours [its rays] upon the half of the moon's globe that faces downward [toward us], and therefore the whole of its illumined half is seen by the inhabitants of the world — and this [is the full moon].

And from the sum of these mentioned matters it will be shown to you that from the two [bounding] rays [קויו] that issue from [the sun?] and widen out from it, and from the two lines of sight [קוי ההבטה] that issue from the eye of the observer at point פ, [the geometry follows]... [that] the two lines of sight draw near, meet, and touch one another thus [•]. And likewise is the rule at the pouring-forth of light at the molad, when the two bounding lines of the observing eye both meet and touch one another thus [•]. And all this is clear, and there is no need [to repeat] the aforementioned considerations of the bounding lines.

שער ח — Eighth Section (The Moon), continued

(Folio [62] סב recto through folio [63] סג verso; running header "שער ח" throughout.)

[§ printed (209) ר"ט = logical §210, continued] — the phases of the moon

[the sun's rays would also have to be drawn as] the bounding lines of the sun upon the sphere of the moon, together with the line of sight and the point of the air upon the sphere of the moon; and because with so many lines the figures would become confused when the moon stands in the other stations, it is enough for the student to grasp [the principle]. I have therefore drawn for them [in the diagram] the cause [of the phase] for a single station only, and from it they will understand the remaining stations.

Know that when [the moon] reaches the [first] quarter — that is, on the fourth [day?] [?] after its molad — the lines and rays of the sun strike it and bound it, illuminating point **א** [aleph] on this side and point **ג** [gimel] [?] on that side, which are the two ends of the diagonal **ס״נ** [?]. This line bounds and divides — in a straight figure across the sphere of the moon — between its illuminated portion and its dark portion. It follows of necessity that the parts of the moon's surface that face toward the sun are illuminated [and the parts that face away are dark]; and the illuminated half-surface [is bounded by the diagonal ב״ד — see below] [?].

And when you extend the line of sight from point **פ** [pe] — the observer's eye upon the surface of the earth — the [two rays] that meet it strike upon point **ב** [bet] and upon point **ד** [dalet], which are the ends of the diagonal **ב״ד**. This

[diagonal] bounds and divides between the moon's portion facing upward — the surface [כ״ה־רא?] [?] — and its portion facing downward. And it is found that this portion, facing downward, is illuminated in its [true] disposition but dark as it is received [by our eye]; so that of the whole surface [כ״ה־רא] [?] there is illuminated toward us, downward, only the surface [ק״ב־ה] [?] of its sphere. This is about one eighth of the whole surface of the moon's sphere, and for this reason it appears in the figure as a portion [drawn?] below like a crescent [שטח משוגם] [?]. For it is impossible to depict either the sphere or a part of it upon a flat surface exactly as it is.

Picture it to yourself thus: if you cut a ball, or an apple, from top to bottom into eight parts, then in the eighth part the upper portion appears to you like a crescent. And just as the law is at the [first] quarter of the month, so the law is at the [other] quarter, which is the [22nd?] day [?] from its molad, when there appears to us half of the moon's illuminated surface, which is a quarter of its sphere. In like manner you may reckon the remaining phases.

Furthermore, know in general [כללן] that the two [middle] quarters [?] ... [the illuminated] portion mentioned to us always [grows/diminishes]... the two quarters [that pass?] toward full [reckoning]... [text partly illegible] [?]

Know further that, according to what **Ptolemy** [בטולמי] mentioned: the arc of the celestial sphere that lies above every horizon is **180 degrees** [ק״פ], through which the moon lies as it travels from the day of its birth to the day of its fullness, about **15 days** [ט״ו]. Thus it advances each day one fifteenth of 180 degrees, which is **12 degrees**; and correspondingly the moon adds to its glow each day one fifteenth of its surface. Now the masters of astronomy divided the illuminated half of the moon's disk into **12 parts**, and they call each part a "finger" [אצבע]. Hence one fifteenth of its surface is **four fifths of a finger** [ד׳ חומשי אצבע], which is the measure of light added to the moon each day. So too the moon delays above the horizon, each day, **four fifths of an hour** more than the day before; for the moon's stay above the horizon is greatest of all the days of the month on the 15th day, when it remains above [the horizon] **12 hours**, as will be explained. For when you divide 12 hours by 15, there results for each day [four fifths of an hour].

And since these matters are all interconnected, gather together for yourself the essentials of the subject, set it out in order, and we shall begin from the moment of the molad.

Know that according to what he mentioned in our composition [that at conjunction the moon is hidden] from all people: when the moon stands aligned directly beneath the sun, with the dark half of its sphere facing downward, it does not illuminate the inhabitants of the world at all. Know that from a time about **24 hours** after the moon stood in its darkness [i.e. after the molad/conjunction], there will then be seen in the moon a horn [קרן, crescent] after the setting of the sun, in the south-western quarter — a glow and a light like a very thin arc, [lasting] but a short while after sunset; then the moon sets, on account of the general [diurnal] motion, beneath the horizon.

After this, at the beginning of the second night, when the moon has moved away from the sun eastward by **12 degrees** — which is one fifteenth of the sphere of the firmament, as mentioned — [there is] added [to it] more than one eighth… one fifteenth of its surface, which is four fifths of a finger as above; and thereby the moon delays from setting also one fifteenth [part]… [about four fifths of an hour], which is four fifths of an hour. And such is its rule: it is able to return eastward and to move away from the sun by 12 degrees [each day], and in proportion as it moves away from it, so it thereby adds each day four fifths of a finger to the light it receives from the sun, more than the day before, and it lengthens its stay above the horizon by four fifths of an hour more each day — all by the approximate reckoning — until the eighth day from the molad. When the moon has then moved away from the sun eastward [or the half of the moon's sphere facing toward the sun], its illuminated [half] is seen — or its glow — by the inhabitants of the world, from the half that faces [us], a quarter of the whole sphere of the moon; and this is the time of the [first] quarter of the month. It then gives light above the horizon for [several?] hours until the [middle?] of the night, when it sets. And such is its rule from the time of the first quarter of the month onward: each night it adds four fifths of a finger [of light] and likewise adds four fifths of an hour to its stay above the horizon, until the [15th] day [ט״ו?] from its molad. Then the moon has moved away from the sun to the utmost distance, which is about **180 degrees** [ק״פ] — the [span] it takes [to travel] from east to the far [point of the] west — and then sun and moon stand aligned, facing and opposite one another, this over against that; this is called by the astronomers "the time of opposition [nagud]," as above. Then the whole illuminated half of the moon's sphere — all its surface — is seen by the inhabitants of the world, and the moon is called "at its full," [remaining] above the horizon a full **12 hours**, opposite [the sun].

[From full moon] to the end of the month it reverses: just as the moon had been going and increasing its light, so now it goes and diminishes it; and just as it had

been going before the [sun] and rising ahead of it, now it pursues after it and draws near, [moving] each day 12 degrees, and delaying its rising and setting above the horizon, after the beginning of the night, by about four fifths of an hour. And such is its rule all the days [thereafter]: it delays its rising above the horizon each [night] four fifths of an hour more than the night before, until at the third quarter of the month the moon rises above the horizon at midnight. And by the same measure and proportion by which the moon had increased its light — from the time of its molad to the time of opposition, four fifths of a finger each day — so from this time onward it goes and diminishes, losing a horn [limb of light] each day by four fifths of a finger, until [none of its light remains to it].

It loses its light little by little until it grows faint and dwindles beneath the sun as at the beginning; and this is the end of the month, and there it begins [to be revealed] a second time. Between one conjunction and [the next] conjunction, the Sages, of blessed memory, [reckoned] **29 days, 12 hours, and 793 chalakim** [ב״ט יו״ב תשצ״ג], as will be explained further on, in § [213] ריו"ג. And it is found that at the beginning of the month, and likewise close to the molad, the moon appears to us [enclosed?] like horns [a crescent], and not so does it appear later in the month. From what has been said it is also clear that the body of the moon is a sphere: what [is illuminated?] of the moon appears to us at the beginning of the month, in its darkness and its remoteness from the sun — after about one day — [is only] some small part, by way of example about half a finger only, which is one part in twenty-four of the surface of the illuminated half of the sphere [?]… as when you take a ball or an apple and cover the whole surface of its sphere, leaving exposed only a small strip of its body from its top to its bottom — a band of [some] width — and diminish [it] from both sides, upward and downward [?].

And as to what may be asked — namely, that the sight of the moon's horns sometimes faces toward the east and sometimes toward the west: [the answer is] that at the beginning of the month… the sun sets before the moon, and the moon still remains above the horizon while the sun is setting, [its light passing] over the sphere of the moon from west to east; and because part of the moon inclines, in its tilt, toward the sun that is in the west, it is illuminated from that [side], while the interior of the moon and its horns face and look toward the east — not toward [the sun] [?]. And after the middle of the month until [its] end, the matter is reversed: the moon sets and rises above the horizon [later than the sun]… [rising] toward the east while the sun has already [set] far off in the west; and because then too, in its tilt, part of the moon faces toward the sun in the west [recte: east], it is illuminated on that side, so that the interior of the moon and its horns face and look toward the west — likewise not toward [the sun] [?]. To this

Chazal alluded in their remark, "Never has the sun beheld the deficiency [waning face] of the moon."

A useful [sign] [ותועלת]: to grasp, at first glance, whether the moon is waxing large or is of a waning size, I will tell the young students what [our teachers / the townsfolk] [?] do to make a fine mnemonic. This is [a quick one]: whenever the [new moon] is [born], picture the moon as resembling [the shape of] a [left?] hand [?], long/arched, until they complete it [to full] and reach thus the [full] place of the moon; and it returns and they diminish [it] again, [and so] the interior of the moon [is read]… the moon still, gently, waxes large — and for this reason it was still [in the first] half of the month; and whenever [it appears turned] from below… half [full] in its interior… it goes and wanes; and this is [when] it is past the middle of the month.

סימן ר״י [printed §210 = logical §211] — [The figures (phases); estimating the moon's visibility and its waning, and how long it remains above the horizon each night]

Heading, verbatim: **סימן ר״י צורות ושער גדולה היכרו ומיעוטין ובמה שעורה ישאר כל הלילה ממעל לאופק** — "Figures; and to estimate the magnitude of its recognition [visibility] and its diminutions, and by how much [time] it remains all the night above the horizon." [reading of some words uncertain]

Since these matters, when set out [in words], are clearer to students [when they are drawn], I have decided to show them a **third figure** [placed] before you, in which the student may see with his own eye all the matters — namely, how the moon, from the beginning of the month onward, goes and increases its light [until] the middle of the month, [which is] the fullness of light; and from there onward its light goes and wanes. [Look] at each edge [of the wheel] and you will see the figure.

In the [outer] ring, above, are marked the days of the month; and below them are marked how much is the measure and value of the moon's light. And in [inner] circles [are] the numbers of the hours and the chalakim [parts] during which the moon remains above the horizon on that night. For example, in this circle where the letter **מ** [mem = 40] appears, it teaches that on the eighth [day] from its molad the moon appears like the figure before you, that is, half of it is seen full of light; and in the circle below it are the [numeric] parts: the letter **yod** [10 = י] is written, indicating the hours, and below it is written the letter **נ** [nun = 50] [?], indicating the fifths of an hour. And know from this that on the eighth night from its molad its surface illuminates **6 fingers**, which is half its [visible] surface, plus

22 [?] fifths of a finger; and likewise you learn from this that the moon will stand that night above the horizon **[10?]** hours and **2 fifths** of an hour — all by the approximate reckoning. And note that for the precise reckoning we require [detailed] computations, fine points, and many conditions.

Diagram. A large circular phase-wheel (a schematic volvelle) occupying nearly the whole of folio [63] סג recto, referenced by §210–§211. Concentric rings, read from the outside inward:

- **Outermost ring:** thirty small moon-disk illustrations showing the phases in sequence around the wheel — solid black (new moon / conjunction) at the top, progressing through crescent and half-lit stages down the right side to fully open (white = full moon) at the bottom, and back to black up the left side.
- **Next ring inward:** the days of the lunar month, single Hebrew letters as numerals. Legible at the top: [1, 2, 3] **א ב ג** with [30] **ל** adjoining day 1 at the top; [27, 28, 29] **כז כח כט** and further day-numbers continue around. The full run 1–30 is intended, but many individual cells are abraded.
- **Two further inner rings:** numeric values — the fingers of light, and the hours-and-fifths the moon remains above the horizon each night (e.g. near day 8 a cell reads [40] **מ**, with **י** [10, hours] and **נ** [50, fifths] below, per the §210 example). Most interior numeric cells are illegible or uncertain on the scan.
- **Center:** blank.

Legible ring-labels are limited to the day-number ring (partial); the two numeric interior rings could not be read cell-by-cell. (more than two labels uncertain).

סימן רי״א [printed §211 = logical §212] — that the hour-computations above are reckoned by the temporal (seasonal) hours

Heading, verbatim: **סימן רי״א שהחשבונות והשעורות הנזכרים בסמוך הם דוקא ע״פ חשבון השעות הזמניות וטעמי קביעות שעות אלו** — "That the computations and measures mentioned nearby are specifically according to the reckoning of the temporal [seasonal] hours; and the reasons for fixing these hours."

Know that all that we mentioned just now, in the count [of the phases] in § [ר״ט 209] and § [ר״י 210] — that such-and-such hours the moon remains for us above the horizon — all of this is exact for the inhabitants [of the equator] only [?], or [for anyone] at the time of the equinox of Nisan and of Tishrei, when for all the inhabitants of the climes there are always **12 hours** of day and **12 hours** of night.

[At those times the temporal hours equal the equinoctial hours,] so that in every other [case the reckoning must be adjusted].

this is not so [at other seasons], for it cannot be that a single [reckoning] in this matter should suffice for all the months of the year. Consider [that] at the time of the winter solstice of Teves [תקופת טבת]… for the inhabitants of [Persia? — פרס] [?] [the moon remains above the horizon about] **36 [?]** hours [ל״ו], while at the time of the summer solstice of Tammuz the moon remains for us only [a few] hours. (And we shall not be exacting here about the small discrepancy caused by the tilted sphere of the moon.) So too, by reason of the variation in the two [seasons] and the times when the moon is hidden above the horizon at the two [equinoxes] — [which are] equal, this to that — [it differs]: as when the moon is seen [in winter] and remains for us above the horizon, by way of example, **9 hours**; whereas in the month of Tammuz, [when the season] has changed, at that time the moon remains for us above the horizon only [a fraction of that] [?] — know that these are [seasonally reckoned].

For what we wrote above [gives] uniform totals for every month, and we did not distinguish [there] any difference or divergence according to the seasons of the year — neither between a month [and month], nor between a season whose nights are short and a season whose nights are long, nor any difference between one region and [another]. This is because all the [computations] mentioned above, in the two adjoining [simanim] ר״ט and ר״י [209 and 210], are founded upon the **temporal [seasonal] hours** — dividing, on every single night of all the days of the year, the measure of that night into **12 equal parts** [שעות זמניות]; so that on the short nights of summer they are 12 short [hours], and on the long nights of winter they are 12 long hours. The [simanim] mentioned above are not uniform for all the months of the year. The example is this: [on] the [25th?] [?] day from its molad [the moon] gives light to us above the horizon for about **9 hours**; for when you divide the measure of [the] night into 12 equal parts, [the moon] will be above the horizon for [nine of them?]. [To take] a case: like a season whose night-measure is about **15 hours** [ט״ו] — the moon remains above the horizon [a quarter of the night-measure, which is 3 hours]; whereas [in another case] its quarter of the night-measure, which is **12** even [equinoctial] hours [i.e. counting from midnight?]… and [in a case] whose night-measure is **8 hours**, the moon remains above the horizon **three quarters of the night**, which is [six?] even hours. Such is the pattern; and so [it is with] all the [computations] mentioned, for all the days of the year. So too, [if we wished to reckon] by the count of the equinoctial [even] hours, we should have needed [a separate reckoning] for each and every month of all the days of the year.

סימן רי״ב [printed §212 = logical §213] — the duration of the moon's concealment each month, its cause, and the [timing] of its [renewed] visibility

Heading, verbatim: **סימן רי״ב מזמן סתירת הלבנה [כל] חדש וסיבת וקדימת ראייתה.**

The moon is concealed each month for about **2 days** [ב׳ יום] — that is, [it is invisible] for close to **24 hours** [כ״ד] before the molad, and [likewise] after [the molad] for close to 24 hours. Accordingly, the moon is not seen [near conjunction] for about two days [and it is then gathered in]. But know that this reckoning is not always exact, for there is in it advance and delay at times: [the interval] may be filled out to about **4 or 5 hours** less than 24, or more than it, whether before [conjunction] or after. For the time of the moon's visibility, between one molad and [the next], by the ancient reckoning, does not stand upon a single side, but there is advance and delay — because [some] factors, when the [conjunctions] draw near [and are at their least distance], [hasten the visibility], while there are other factors, opposite to these, that delay and [hold it back] far from the moment of the ancient [mean] molad. As [Isaac] Israeli wrote [?]… [the sage said]:

until, at a time when it is [close?] [?], its light is manifest [enough] to be seen by our eyes; and moreover [when] the moon's place of setting has drawn far from the sun's place of setting, until [the sun's light] fails to [overpower] the moon's receiving of its light; and third, [when] the moon inclines toward the north at the extremity of its latitude, so that part of its day is somewhat greater than part of the sun's day, and it lingers a little [longer above the horizon] before setting beneath [the sun]. When these known factors are combined — in longitude and also in latitude — and, conversely, when the said factors [are combined in the opposite sense], then the [renewed] sighting of the new moon is delayed and postponed. To this matter Chazal referred in the first chapter of [Tractate] Rosh Hashanah: "Sometimes it comes by a long [route] and sometimes by a short [one]." It is set out explicitly in the *[Hilchot] Kiddush HaChodesh* of **Rambam** [מיימוני מהלכו] [?], [chapter] ק״ה, ch. 8 [?], law רע״ח [?].

When the motions of the sun are [swift] (as above, about **183** [קפ״ג] [?]) and [that of] the moon is [slow] (as above, about **139** [קל״ט] [?]) [?], the time of concealment is shortened; for the moon has in it three causes: when the sun's motion is swift and the moon's motion is slow, the time of concealment is very long, because the moon does not overtake [the sun] until a long time [passes]; and when both of them are swift, the time of concealment is short — though not so short as in the first case; and when the motion of both is slow, the time of

concealment is long — though not so long as in the second case. But know that all this is by the reckoning of exactitude for the sighting of the moon. [The moon becomes visible again] at about **26 full days** after the molad [?], and there is no case in which the moon's [invisibility] is delayed more than **30 days** [ל׳]. And know that all this that we have mentioned is what follows from the ancient [mean] molad — [with the modifications that follow]. Sometimes the [interval of] concealment [reaches] as little as [a short span]… up to **240 [?]** degrees [ר״מ] for a long time [of visibility], while the mean [elongation] is **12 degrees**. And this suffices.

סי׳ רי״ג [printed §213 = logical §214] — the measure of the lunar month, which is 29d 12h 793ch, whose [reason?] is unknown to us

Heading, verbatim: **סי׳ רי״ג מדת חדש הלבנה שהוא ב״ט י״ב תשצ״ג [ו]מ[?] אין נודע לנו.**

Know that the measure of the lunar month — from the time [the moon] renews itself [at one molad] until it renews itself a second time, in its mean motion — is already a tradition received in our hands [that it is] **29 days, 12 hours, and 793 chalakim** [כ״ט יום י״ב שעות תשצ״ג], [with a remainder] hidden [and folded?] within the hour [?]. It is a deep and wondrous computation, and more [wondrous] than all the computations of the ancient and the later astronomers. The sages of the nations of former days already established it for us; and I have elaborated upon this in my book, *Ma'or HaKatan* [מאור הקטן] [?]. The sages of the [gentile] nations too composed [works] on this matter, [as it is] their manner…

שער ח — Gate Eight (continued)

(This page opens in the middle of Gate Eight, on the moon. The running header "שער ח" stands at the top of each of these four pages; Gate Eight itself was opened in an earlier gathering.)

[Continuation of סימן רי"ג — printed 213 / logical count §214]

(The tail of the preceding siman, on the length of the synodic month — the molad interval of 29 days, 12 hours, 793 chalakim — and whether it is a tradition from Sinai or a computed value.)

devoid of and lacking the mathematical science, the science of the stars, and the science of the constellations — [and one] wondered at how [one could arrive at] the computation of the Talmudic sages. [Some ask:] who has told us, or from whom has it been made known, the intent of the computation? To compilers such

as these it appears that [the derivation of] the astronomy involves great inquiry and much [study]. Some say that this computation is a halacha [given] to Moshe at Sinai, like many other matters handed down [in] the Mishnah and the baraita. And [it is cited] in [tractate] Rosh HaShanah, folio 25[a] [?] (דף ו"ה [recte כ"ה]) [?], where it is taught there [the well-known baraita]: "...[two witnesses] were obscured by the clouds, and the likeness of the moon appeared..." [Rosh HaShanah 25a]. ...[they] reckoned. R. Nachman said: thus I have a tradition from the house of my father['s father], that the renewal (chidush) of the moon is not less than 29 days, 12 hours, two "hands" of an hour [= two-thirds of an hour, 44 minutes], and [793] chalakim [?] more; and it does not appear [to be] less. ...only 29 days and two-thirds of an hour, and not [more than] 793 [?] chalakim; and so the sage Ibn Ezra [ראב"ע] brought it in his commentary [on the word] "sechado" [?] with great precision, and also in Sefer HaIbbur. Also Avraham HaNasi [= Avraham bar Chiya], cited in the first chapter of Sefer Me'or Einayim [?], brings [it].

but the full baraita is not mentioned, and it is written [there] only "29 days and two-thirds of an hour" alone, and it does not [expressly] record the 793 chalakim [?]. There is a further matter as well [?] — as in the chapter of R. [Chananel?] [?] — concerning... the great luminary [?]... [Nonetheless] it appears from the words of all [these authorities] that we have received the reckoning of 29[d] 12[h] 793[ch] [?]; and even so, this tradition is not lost to us — as against [what] some place [would hold] — according to the words of the Rambam [הרמב"ד, recte הרמב"ם] [?], of blessed memory. We do not deny this reckoning: it is a tradition in our hands from our fathers and our fathers' fathers back to Mount Sinai. This is the view of the Rambam, of blessed memory, in chapter [11] [?] of Hilchos Kiddush HaChodesh, [where he writes]: "It is a halacha to Moshe from Sinai that, in the time when there is no fixed Sanhedrin [sanctifying the new moon by observation], we reckon by this computation of ours and compute by it," etc. And that which was not handed down in tradition, or [set down] in any place explicitly [?], [was withheld] because this matter is undoubtedly a secret — [it is] drawn from the roots and foundations of the Sod HaIbbur [the secret of intercalation]; therefore it was not committed to writing in the Talmud plainly, just as we do not find in all the Talmud the reckoning [of] the seasons (tekufos). [Rav Chananel?] [?] wrote... [that this is] the essence, and indeed truer than the tekufos of Shmuel [?]; and we likewise do not find in the Talmud the order of intercalation for the years [of the cycle — the mnemonic נו"ח אדז"ט [?]]. Many others who were sages knew them, but did not transmit them except to close disciples and to the pious of the generation [?] and to the great ones of the Sanhedrin, and not to the rest of the multitude of Israel — as the Rav [Rambam],

of blessed memory, wrote in chapter 11 of Hilchos [Kiddush HaChodesh], and [as] Israeli [= Yitzchak Yisraeli] [wrote] in chapter 15 [of Yesod Olam]. …[And Avraham] bar Chiya HaNasi arranged [this] in his book Me'or HaKatan, in the first gate, siman 15, with the help of Heaven.

סימן ריו"ד — On which place on earth the reckonings of the molados and tekufos were established

(printed 214 = ריו"ד; logical count §215)

סימן ריו"ד — Concerning which place on earth our reckonings of the molados (new-moon conjunctions) and tekufos (seasons/equinoxes) were established.

Concerning the epochs (rashei simanei) of the moon's molados, and likewise the epochs of the sun's tekufos, as they were transmitted to us by Chazal, it behooves us to take pains, to examine, and to determine at which place on earth these reckonings of the molados and the tekufos were established for us.

I say now, by way of illustration: we have [taken, say] the molad of Tishrei at midday on Shabbos. Even though a single molad [holds] for the whole world — as [I] said [?] — one cannot say that at every place on earth it is midday on Shabbos at the moment of that molad; for it has already been explained above, in siman 46 [כסי' מ"ו], that the beginning of the day for the inhabitants of the eastern hemisphere is, at that very moment, the beginning of the night for the inhabitants of the western hemisphere.

Accordingly, if we posit and say that the moment of the aforementioned molad falls, on the meridian [?] of the East, [at] midday of Shabbos — then, when midday of Shabbos reaches [the inhabitants of] the West, twelve hours will already have passed and elapsed for them since the moment of the molad. And if we say that this molad [occurs] in Jerusalem, then all the places that lie to the east of us will have the moment of this molad after midday of Shabbos, and all the places that lie to the west of it will have the moment of this molad before the midday of that day. And even though in truth there is one molad for all of them in a single instant, that instant is, for some, midday; for some, before midday; and for some, after midday. And Chazal concealed from us [?] at which place the [reckoning of] intercalation was established… for the appearance (mar'eh) changes in every place according to the breadth of the land, and according to the distance of the moon from the line of the zodiac, in the length of its appearance — in length and in breadth [?]… [and its rising].

Also the sage Israeli [= Yitzchak Yisraeli] roused [this question] in [his] treatise [Yesod Olam]; he expanded and elaborated in discussing it, and treated this as one [difficulty]. In the seventh chapter [?] he… [made] a great [inquiry], and it grew [into] a great [difficulty], and his resolution of it was a very deep [matter] — "who can fathom [it]?" [cf. Koheles 7:24]. He went far [afield] in [treating] the hidden [side] of this doubt, with [words that are] concealed [?] and obscure. He desired to reveal [it], but the limit of his intent [remains] hidden [?] and slight [?]. And the Rav [Rambam], of blessed memory, said [in] a statement of our Rabbis, of blessed memory: "they instituted [the reckoning of] the intercalation such that day and night are always reckoned as equal [everywhere]" [?]… [as it is stated] in [tractate] Rosh HaShanah [?]… and it was revealed to us in this [that] the years [?]… By this rule [?], the inhabitants of the whole world will always have day and night equal [in the calendrical reckoning], also in the reckoning of the tekufos and molados, [reckoned] as if from [one of] the fixed places on the [meridian] line… so as to know at which [place]… And the portion [?]… so that the intent of the aforementioned computation [is] that the [reckoning] be arranged [?] as in siman 89 (כסי' פ"ט). And I say, moreover, [that it is founded] upon the navel of the earth (טבור הארץ) — namely, [Jerusalem, at] the center of the world, [where] the reckoning of intercalation is founded, in the middle of the world, or [near it]. And the received [tradition] is that the [meridian] line that is [drawn] — which is the boundary [?] separating [?] the East [side] from the West — [passes] through it [Jerusalem], and from it [are counted] the degrees [?]… as we chose [to arrange] in order, as in siman 89 (כסי' פ"ט); and this is the limit of his intent, until it be made known to us [by] one better than we, [and] we accept [his] words. And according to his words it is fitting [?]… to seal [the reckoning] according to the measure of… [along] the [meridian] of the earth; and likewise the molad has [its] fixed time of the tekufah, which [belongs] to the secret of its place.

סימן רט"ו — That the moon appears, after its renewal, uniform for the whole world by a single measure

(printed 215 = רט"ו; logical count §216)

סימן רט"ו — [On the fact] that the moon becomes visible after its renewal [at a uniform elongation] for the whole world, by a single measure [לאיפק [?] לעולם בשיעור אחד].

And if you ask and wonder: since the moon circuits [its sphere], and there is a molad in every orbit (galgal) at a [fixed/measured] time — nearly [equal / completing] [?] — [it would seem] fitting [?] that it should rise upon the horizon [האופק] [at] this molad, until [?]… and upon the rising [?] of… which [is] after the

molad… [it becomes] visible [?] to be revealed from the horizon to us [?]… and every molad [?]… [the several remaining words of the opening are lost to the gutter shadow — ?].

[The moon] [rises/sets] to the horizon [by] 3 degrees [ג' מעלות] [?] in [its] renewal [?]… [along] the line [?]… above the horizon likewise 3 degrees [?]… so that the moon renews itself and becomes visible, after its renewal, throughout all [?] the twelve constellations [י"ב מזלות] in the firmament.

סימן רט"ז — That no star completes a full revolution in the time of one rotation of the daily sphere

(printed 216 = ר"ט; logical count §217)

סימן רט"ז — That no star completes a full revolution (sivuv shalem) in the time of [one] rotation of the daily sphere (galgal ha-yomi).

Know that no star, in my view, is found among the stars of the sphere of the constellations [?] that completes [with the daily sphere] a full [revolution]… [each of them] circling the terrestrial globe (kadur ha-olam) — [it makes] a complete circuit [?] in [its own] time. …the sphere circling every day, [it, too, revolves]; and thus is the way of every sphere [?]… [The moon] is quicker in its course than all the [other] spheres… [and each] sphere [?] [makes] fewer [?] circuits [in a day]… [it moves eastward] slightly [?]… For they say [?] that this sphere is [the one]… [that] runs a course quicker in its motion than all… every day, according to their [reckoning]… [the moon], for its part, [travels] more than 12 degrees [י"ב מעלות] each day, so that it lags [only slightly] behind [the daily sphere] — for its deficiency, relative to the [daily sphere's] revolution, is greater [?]… but [it does] not [complete a full revolution]. [The values, and the fine arithmetic here — "793 [?] chalakim," "12 [?] degrees" — are largely lost to fading and are flagged [numeral: ?]; they are not reconstructed.] …and just as the moon [lags], so [with the] deficiency of [each] star… only [that] the deficiency of Saturn [?] is far greater… as I have already mentioned this matter [above]. And it appears from the words [?]… as [in] siman 89 (פ"ט), and it [is]… the sage [Israeli?] [?]… and they call it [by the term] "[the fourth-day?] motion" [?]… in the year 4,000-and-something [ד' אלפים נת...] [Hebrew numeral: ?]], to us [?]. And this is what I wrote [?].

סימן רי"ז — To observe the [mean/true] eastward motion in each of the seven wandering stars

(printed 217 = ר"י; logical count §218)

סימן ריי"ז — To observe the [true/mean] motion (ha-tenu'ah ha-emtza'is [?]) in all seven wandering stars (kochvei nevucha).

The demonstration: concerning the eastward motion [ha-tenu'ah ha-mizrachis] that belongs to the sphere [?], which is not [perceptible to the eye at once]… [but] according to the principles that were selected just above, [and] also above in siman 29 (סי' כ"ט) [?]. For it will not be found in any one of [the seven] from several aspects [?]… Take for yourself one star of the wandering stars whose motion [is such that] it is fitting to detect by the sense [of sight] the [true] motions of the wandering [stars] [?]. …the star that renews [its position]… so take for yourself one star of the [seven]. …Consider [it] again [?] over two [nights], [on] a third [and] a fourth [night]… how far its height [?] has moved [and] is drawn near… above the horizon in the west [?]… and observe upon it, over [several] nights, [on] a second, third, and fourth [night], [and see] how far its height has moved and [how] its motion [is] drawn near [?]. …and this [is done] by seeking the mean motion of the sun, as the sun's revolution [is] in every [day about] 1[°] approximately, above [?]… [For example, Mars] [is such that] within a few days the observers will discern the degrees [it has traversed] in the sphere [?]… [something] that in 28 days [כ"ח דקין recte ימים?] [?]] [?] one will recognize by [near and far / rising and setting], as in siman 18 (בשער הי"ח כס"ד [?])… [the star] is more prepared [than the others] to be observed, [in that] within a few days [its motion is discernible] "to the eye" [?]… [Take] one star of the seven [כוכבי שבת recte שבעת) [?]], [observe it] at the beginning of the night [in its] elongation above [the horizon] in the west, and observe upon it again [on] a second [and] third [night]. …[the star that] renews [its position, at] the end of its elongation, and observe upon it [?]… [Do not] err [?] to say that thus each star among the wandering ones would be found to have motions proportional [to it], each star according to a distinct path [כפי מסלך מיוחד].

סימן ריי"ח — Some hold that there is no [true anomalistic?] motion, nor eccentric sphere, nor epicycle

(printed 218 = ריי"ח; logical count §219)

סימן ריי"ח — Some say (yesh omrim) that no [true] motion (tenu'ah ha-zaka [?]) is found, and no eccentric sphere (galgal yotze merkaz), and no epicyclic sphere (galgal hakafa).

Know that from the days of the sages of old, and [still] earlier, [among] the ancients, there arose certain sages who probed deeply and gained understanding in the science of the stars and the constellations. They deliberated and took it to

heart to abolish [!] the principles and foundation of Ptolemy [בטלמיאו"ס], and of [Copernicus?] [ומברכו"ם [?]], and of al-Battani [אלבתאני = וחלב"תיני [?]], and of the rest of the sages [?]. These [men], as their sages [held], said that no eccentric sphere at all is found, and no epicyclic sphere, and that there is in the world nothing but nine spheres [ט' גלגלים [?]] — [each] complete in its [own] simple [uniform] motion, and they gave a reason and offered [an account] to explain their words. For they say that all the motion of the celestial spheres — all of them — is essential (atzmi), from [west] to east, in accordance with the daily motion [?]; and the extremity [?] of them [wishes]… [the ninth sphere] which is the world[-sphere?]… [as the sages of Israel wrote, as in] siman 89 (פ"ט) [?], and it is theirs [?]… [and it is called] by the name [that]… some called it… "the [?] motion"… [and] some [called it] by [various] names [?]. …and further, the moon [and the rest of the wandering stars move up and down] [?]…

But in their [own] view — according to the opinion of Israeli [Yisraeli], as they explained [it] — for every… [the poles of the sphere of the constellations are one thing, and the poles of the diurnal sphere another]… [there are no eccentric spheres, only] the poles of the sphere of the constellations, which alone [account for the appearances]… [and this is] why this [and that] differ, that the poles of [one sphere are drawn away] from the poles of [another], and in this way [the appearances are saved] without eccentrics… [In] my view [?], every [motion may be accounted for] by a small pole [?], a star [that is] deep [?]… around a [minor] pole of a sphere [?]… [and thus] "the star of Saturn" [?]… [descends and] its height [?]… [some fading lines here are illegible — ?].

[Continues, on p.131 → p.132, arguing the homocentric-sphere scheme in Ptolemy's name and citing Kepler.] …[I heard] from the mouth of the sage Kepler [מפי החכם קעפליר [Kepler] [?]]… [that these] sages [as the ancients?]… before [Averroes / Ibn Rushd?] [אברכו"ם [?]] and Ptolemy [ובטולמיאו"ם]; and still further [?]… [what] the sages knew, and what they did not, some of them held [thus]… [as] Israeli [Yisraeli] wrote, to explain [?]… [The astronomers] did not agree [?] to [posit] complex [epicyclic] motions — [they held] only [?] as [Israeli] held [?]… [The moon and planets move] up and down, and toward the poles [?]… [now] to the north [and now] to the south; [now] they draw near to the terrestrial globe, and [now] they recede from it. And since the matter is so, we shall have no need of any eccentric sphere, nor of any epicyclic sphere at all… at the outset of the revolution [?]… and [it is] more fitting [?]… to the view of Ptolemy [בטלמיאו"ס]… to say that the "princes" of the spheres [שרי הגלגלים] are nine [in number], corresponding to the nine motions seen in the firmament, and all of them agree upon one simple [uniform] motion… [set] for each star; and [it revolves] not

about a fixed center — as the moon['s], whose center [is such] that [at one point it is] high and [at another] low [?] — [i.e., no] epicyclic sphere… [All] these matters are [what] they [?]… [and the like] every question [is asked] of them [?].

And Israeli [Yisraeli] further wrote, in the aforementioned chapter, that if these [men]… the star… [gave account of] their doings and offered a fitting reason for… the variation… and [the appearances of] the stars at all times… and all of their [ways], like this, [accord] with Ptolemy [בטלמיאו"ס]. Most of the sages [?]… are agreed with them [?]… and incline to the reasoning of [?]… since the [later] sages [?] decreed [thus]… all this [is] out of [intellectual] indolence [?]… for it is [that they] cannot [establish] correctly [what is fitting], or that [the eccentric scheme] did not suffice for them [?], and they did not draw support from [them at any] time… to accomplish their doings according to [their] principle… so as to guard our view [?] [in accordance with] their reasoning entirely… [along] the way of Ptolemy [בטולמיאו"ס], and of those who walk in his footsteps who founded it and clarified [it]… as [in] the aforesaid matter — several times [it is] correct and clear. So far [this matter].

סימן ריט — How great is the [apogee] height [of the moon] from the center of the earth, and the difference between its near and far [distances]

(printed 219 = ריט; logical count §220 — this is the closing siman of Gate Eight)

סימן ריט — How great is the height [rum / apogee] [of the moon] from the center of the earth, and the difference between [its being] near to it and far from it (rachok mimenu).

To know how great is the [apogee] measure [of the moon] from the center of the earth, and the difference between its height (rum) and its lowness (shefel) — [a] difference [that lies] in the sphere [of the moon] [?]. It is [equal to] the thickness of half the breadth of the moon's [epicyclic] sphere [?] in its revolution. Know that at the outset [we shall begin]… and know first that there is a disagreement between the sages of old and the later ones, and [the] writers [?]. According to the view of Ptolemy [בטלמיוס], the far [distance] of the [moon's] center… every astronomer wrote… of the moon from the center of the earth, [such] that [its greatest distance] and the limit of its nearness [are] chalakim [and] 33 [?] canes [ל"ג קנים [numeral: ?]]… [equal to] the thickness of half the terrestrial globe — that is, from the center of the earth up to the surface, which is [458?] [ת[ת]"ן [Hebrew numeral: ?]] parsa'os, [in] parts [of a] mile [?] approximately). Thus, in his [Ptolemy's] view, the difference between the far [distance] of the moon from

the center of the earth and its near [distance] is [33?] canes [חל"ג [recte ג"ל?] קנים [numeral: ?]]…

[so-and-so] canes, and its near [distance] 33 [?] canes [חל"ג קנים [numeral: ?]]… as is the received [figure]… Those who side [with] his view [make it] 16 canes [ט"ז קנים [numeral: ?]]. And by the exact investigation of the great scholar Tycho [טיכ"א = Tycho] Brahe [כרהא"סי / ברהא"סי [Brahe]] and his associates, they [found] [?] that the height [apogee] of the moon from the center of the earth is [so-many] canes, and its near [distance] 33 [?] [חל"ג]; so that the difference between the near and the far is only 58 [?] [ח"נ [numeral: ?]] canes. From all the aforesaid matters… it is found that the difference between the near and the far, in the view of Copernicus [קופרני"קוס], is but [?] as the difference [that is] in the view of Ptolemy [בטלמיוס]; and the difference in the view of Tycho Brahe [טיכ"א ברהא"סי]… [is] only about [?] [that] of Copernicus [קפערניקוס]… [and their part is according to?] the view of Ptolemy [בטולמיאו"ס].

And I, who write this, heard [it] from the mouth of the great investigator Tycho Brahe [שמעתי מפי החוקר הגדול טיכ"א ברהא"סי — Tycho Brahe], [that] according to his method and his inquiries by [instrumental] measurement, he said, from [his own] reasoning and [as one who] savors [truth] [?], [that it is worth] two thousand [?] to trust his received method [?]… just as [do] those who side [with him] [?], [it is] as great as [some] 31 [?] canes [ל"א קנים [numeral: ?]]; for if it were so, it would follow that its measure, in being double its height [?], would grow ever greater and greater. It is [thus] found that its measure at [apogee] height [is]… [With this] we conclude the eighth gate.

(Closing line: "בסיומנו שער השמיני :" — "With the conclusion of the eighth gate.")

השער התשיעי — Gate Nine

(Body heading, p.132)

השער התשיעי — In it is explained the darkening (kadrus) [that is] the eclipse of the sun and the moon, and their cause[s]; the factors that produce them; and [the fact] that the solar eclipse is seen in one place entirely and in another [place] partially — [visible] from one [region] but, in another region, not to all together — together with the principles and the foundations proper to them.

סימן ר"ך — On the eclipse and darkening of the moon

(printed 220 = ר"ך; logical count §221)

סימן ר"ך — On the eclipse and darkening (lekui ve-kadrus) of the moon.

After we have explained above that the courses of the two luminaries [the sun and the moon]... when the cause [is] the circles that produce [the eclipse] [?]... the moon at the time of opposition [i.e., at the full moon, opposite the sun] [?]... [when] the surface [?] of the face of... [is darkened]... [it is deprived of light] from the sun at times; [and the sun,] at times, at [the moment of] the molad [i.e., the new moon] [?]... [is hidden] from some of the inhabitants of the world, and [is eclipsed as to] one part of them... And according to our holy tradition [it is called] "kadrus" (darkening), from the language of the verse — "in the heavens I will darken them (akdirem)" [Yechezkel 32:7–8: "and I will darken (וְהִקְדַּרְתִּי) all the bright lights of the heaven over you... and the moon shall not give her light"] — "and the moon [shall not give its light]"... [whereas] the sages [call it] by [the term] "lekui ha-me'oros" (eclipse of the luminaries) [?]. And we shall begin...

[The following paragraph is the tail of the preceding siman (printed §220 / ר"כ; logical 221), continuing from the previous page.]

Since the nature of our sphere — the body of the moon — is that of a dense, dark body, in itself opaque by nature and having no light of its own, it receives its light solely from the ray of the sun. It is like a polished mirror of iron and burnished copper, buffed bright, which — when you set it opposite the sun — sends back from itself a gleam and a shining radiance. And once this is known to us... the moon's light grows and increases until the middle of the month [full moon], and from then on it turns back and diminishes until it is cut off from it entirely, as was explained above in siman [209] ר"ט. As for the eclipse that befalls the moon, which happens to it as you will understand — know now that when the moon stands opposite the sun with the earth entering between the two of them, the earth's globe blocks and separates between the sun and the moon; this interposition acts like a screen [drawn across], able to cut off the sun's rays from reaching the moon, so that the moon is darkened for lack of the sun's light on account of the earth's blocking. Therefore, when it grows dark, this is what the sages call the eclipse of the moon. And this occurs only when the two luminaries are exactly aligned, set opposite one another, with the body [of the earth] precisely between them, at the moon's full — which at the moment of opposition [nagud] happens as stated above in the manner of siman [209] ר"ט. This, in general, is the cause of the moon's eclipse.

סימן רכ"א [printed §221; logical 222]

The nature of the earth's shadow — that it goes on tapering as it extends, and that when the moon enters into it, the moon is eclipsed.

Already we explained above in siman [104] ק"ד concerning the shining of the sun... upon the surface of the earth. The earth's shadow [is cast] like its own image and is pointed [conical]. Now if the earth's globe were larger than the sun's globe — or if the earth's globe were exactly equal in measure to the body of the sun's globe — then the shadow would run on at an even width all the way up to the sphere of the zodiac, and then the moon would be eclipsed not only at full [opposition]... [text degraded]. But because it has already been demonstrated to the sages by clear proofs that the sun's diameter is greater than the earth's diameter by five and a half times [Hebrew: ה' פעמים ומחצה], as was explained, it necessarily follows that the sun overhangs [with its light] more than half the earth's globe, [wrapping around] it on all four sides. Because the sun so greatly exceeds the smallness of the earth's globe, the shadow upon the earth goes on tapering to a point until it returns to point א [alef], beyond which the shadow ceases altogether.

Diagram. The earth's shadow-cone. A large circle (the earth's sphere / the sun's body) with a dark hatched cone extending from it to a point; a smaller circle at the lower left carries the label א. The construction is described in the text: the line passing through both centers, א–ב–ג, is the axis ["amud"].

- א (small circle, lower left): center of the sun [מרכז החמה]
- ב [bet]: center of the earth [מרכז הארץ]
- ג [gimel]: the apex and end of the shadow [ראש הצל ותכליתו]
- ד [dalet], ה [he], ו [vav] (on the bounding lines of the cone): endpoints of the lines issuing from the sun that delimit the shadow [labels partly worn: ד/ה/ו]

Point א is the center of the sun and point ב is the center of the earth; point ג is the head and terminus of the shadow. The line passing through the two centers and crossing the earth's globe is line א–ב–ג, and it is called the "axis" [עמוד]. The head of the axis, which is the terminus of the shadow, stands exactly opposite the place of the sun's center. The lines issuing from the side of the sun that bound the shadow are line ד–ו and [line] ג–ס [?], and triangle ג–ס–ד [?] serves as the divider... The astronomers of the science of the spheres estimated that this whole tapering cone passes through the thickness of the elemental sphere, through the thickness of the moon's sphere and the sphere of Mercury, and enters into the sphere of Venus. When the moon enters, where the shadow is, it is eclipsed. The measure of this shadow's length, from the surface of the earth to its terminus, the sages estimated at [? 188] קפ"ח "cords" [חבלים], being the whole of half the earth's diameter [and more]...

The earth together with its shadow, all darkness and tapering to a point — when the moon in its orbit enters within this shadow, the earth's body being midway between the sun and the moon: if the moon enters wholly within the shadow at opposition, with its center on the straight line א–ב–ג, it is wholly eclipsed; and if only part of it enters into the shadow, only that part which enters the cone is eclipsed, while whatever projects out of it — whether to the south or to the north — [is not]. The remainder of the shadow keeps tapering and diminishing as it descends... When [the moon's] circuit is near the earth's globe its darkening is greater [and it] is more hidden; when its circuit is farther from the earth's globe [it is less hidden]... [several clauses degraded].

סימן רכ"ב [printed §222; logical 223]

The form of the inclined circle of the moon [עגול הנוטה], and that every eclipse is at the head of the node or at its tail [ראש התנין / זנב התנין].

Already we explained above in siman [189] קפ"ט that the sphere of the [moon's] star... lies within the sphere... of its star and is aligned... [the deferent], and the inclined sphere [גלגל הנוטה] tilts from one side toward the north and from the other side toward the south... the inclined circle from the straight [ecliptic] circle in this way... the tilt of the [inclined] circle... as we explained with the [foreign astronomers]... as in this figure.

Diagram. The inclined circle of the moon crossing the ecliptic at the two nodes. Two intersecting circles with a horizontal diameter; foreign-language (Latin/vernacular) labels appear on the arcs together with Hebrew point-letters. Several labels are worn and not securely legible.

- Outer arc (top): אופזהבוטה [transliterated term, uncertain — [?]]
- Inner (across diameter): אופזהרמה [transliterated term, uncertain — [?]], with ד [dalet] above and ג [gimel] below the diameter
- Left side (outside): letters אשם / אטש [?]
- Right side: מהב [?]

סימן רכ"ג [printed §223; logical 224]

Why the moon is not eclipsed every single month when its center is opposite the sun's center.

As for why the moon is not eclipsed in every single month, when the moon at its full stands opposite [the sun] and the two luminaries are aligned against one another at opposition — know that if the moon's course ran exactly beneath the

course of the zodiac, as the sun's course does, then the moon would be eclipsed at every opposition and full moon of every single month. [And were it not for the laws and rules of the head of the node and its tail, and so forth.] But because the moon's carrying-sphere [גלגל המשא] is tilted away from the line of the zodiacal circle — inclined on one side to the north and its other end [to the south] — it therefore follows that it is not the case at every opposition that the centers of the sun and moon, together with the center of the earth, all fall on a single line; for the moon deviates in latitude across the breadth of the firmament. Hence, at most oppositions, the earth's globe does not come between the two luminaries.

In some of the months, at opposition, the moon fills [with the sun's light] and reaches the head of the sign of Capricorn... [degraded]; and if the moon's course ran beneath the sphere... then the moon would stand opposite it, [with the head of] the sign of Cancer... and all three centers would lie on one line, and it would be eclipsed. Yet the moon is not [eclipsed] every month, because the moon deviates in latitude — from the sign of Cancer up to [numeral: 67 = ? ז"ס? — value uncertain] degrees, since the moon [is tilted]... Because [the moon's inclined circle is set at a slant], at most months the earth's globe does not interpose between the two luminaries, and no eclipse occurs at all across the earth; only [when it is at the node does it escape and the sphere completes its eclipse].

סימן רכ"ד [printed §224; logical 225]

That sometimes the darkening is found in the moon only in part of its body, and when the moon escapes eclipse entirely.

Know that the sages estimated the measure of the breadth [of the shadow] across its whole... and its diameter at the place where the addition of the moon's tilt [begins], which is an arc of [numeral: ?] and is about a degree and [a fraction] — [numeral: ?] degrees on the inclined sphere, where half the thickness of the shadow is tilted toward the north of the line of the tilting-node and half to its south. The diameter [of the moon] they estimated at close to two degrees [numeral: ~2 ?], half of it likewise tilting to the north of the node-line and half [to the south]... which [text worn].

[Continuation of §224]

[the moon] climbs upward, and therefore when the moon deviates from the point directly opposite the sun by the width of the firmament — about a degree [numeral: ?] — the moon will not escape eclipse altogether, according to the near reckoning; that is, when the moon draws away toward the north, deviating in the

breadth of the firmament by three quarters of a degree [numeral: ג' רביעי המעלה ?], which is [near] the extent of its latitude, it will not fall upon the line... Thus the moon, whose diameter measures some degrees and is roughly [a degree], as it circles upon the node-line by [about a quarter-degree], will begin at its immersion to enter into the shadow... So when the moon is found near the node, by less than one degree, it will in any case be eclipsed, whether much or little, all according to its nearness to, or distance from, the node or from the head of the dragon. As for the standing of the moon in longitude across the firmament — when it does eclipse — the Israeli [R. Isaac Israeli, in *Yesod Olam*] wrote, citing Ptolemy [בטלמיוס], in maamar [numeral: ?] siman [numeral: ?]:

At the near opposition [reckoned by first approximation], call it "the near"[?] — whether before it or after it, less than [numeral: קי"א ? — perhaps eleven] degrees in the longitude of the firmament — the moon will in any case be eclipsed; and if it is farther from that, a little [more], it is possible that it is eclipsed a little, and possible that it is not eclipsed at all; and if it is farther from them by [numeral: 12 = ? י"ב] degrees and [numeral: 12 = ? י"ב] regaim, or more, there is no way it can be eclipsed at all. And at the mean opposition, when the moon's center is [numeral: 15 = ? ט"ו] degrees [and] [numeral: 12 = ? י"ב] regaim [from] the node or its tail, it is impossible for it to be eclipsed at that opposition.

סימן רכ"ה [printed §225; logical 226]

That the astronomers divided the times of the moon's eclipse into five periods.

The astronomers reckoned, regarding the moon's eclipse when its whole body is enfolded [in shadow], five periods — and for [some, six or seven] — of the several [stages] the writers set down in [treating] the eclipses. And these are, in [order]:

- **First:** the moment the moon begins to enter within the shadow-circle, when its whole body begins to be darkened from its eastern edge.
- **Second:** the time all its body enters the shadow-circle [total immersion].
- **Third:** the time of mid-eclipse — the time the moon's center stands opposite the center of the shadow.
- **Fourth:** the time its body begins to emerge from the darkness and to turn back and recover light, when its western [?] edge begins [to shine].
- **Fifth:** the time of the end of the eclipse, when the moon comes out of the shadow entirely and returns to shine with its whole body as before.

There are really only three [key] moments in the eclipse: the time of the beginning of the eclipse, the time midway through it, and the time of the end of the eclipse.

סימן רכ"ו [printed §226; logical 227]

The eclipses of the sun; and that there are several differences between its eclipse and the moon's eclipse.

The sun's eclipse has laws and rules many times more numerous than the moon's eclipse, for [in the moon's eclipse] the darkening is in its own body and in its own being; whereas [for the sun the eclipse is] at a [particular] place... it is eclipsed for [some of] the whole world... Likewise, sometimes the sun is eclipsed for [the inhabitants] of some regions and in other, neighboring regions it is not, [and it is not the same for all] — as will be explained; and it is far easier for the sun to escape eclipse than [it is for] the moon. Know, then, as a general rule, that the calculation of the sun's eclipse has many rules and conditions, and on that account it is a great and deep matter, exceedingly [profound]; and I cannot elaborate on all these matters — I will set before you only a few of the more essential points, and all in great brevity.

סימן רכ"ז [printed §227; logical 228]

That the cause of the sun's eclipse is that the moon stands before the sun and blocks its light.

The sun's eclipse is not from the sun's own side, for its body is not eclipsed, nor darkened, nor is any light at all diminished from it. Rather, the cause of its eclipse is that at the end of the month, at the time of the molad [new moon], when the sun and the moon are aligned one directly opposite the other, the moon at times blocks between the sun and a person standing on the earth's globe. So opposite the sun nothing is changed and nothing is diminished; only the body of the moon interposes between the body of the sun and the eyes of people, preventing them from seeing the sun — like an eye [screened]... which prevents its circuit [of vision] from [reaching] the rising of the sun. This, in general, is the cause of the sun's eclipse.

סימן רכ"ח [printed §228; logical 229]

How the moon, in its smallness, covers and hides from view a thing more than three thousand times larger than itself.

And if you should ask and say: How, in the moon's [work of causing] the sun's eclipse, does the body of the small moon block and prevent the light from reaching us? — for the body of the earth's globe is larger than the body of the moon by [numeral: 39 = ל"ט] times, as was explained earlier in siman [רל"ט 239]; and the whole body of the sun, the length of whose diameter is greater than the earth's diameter by five times and a fraction [numeral: 5 = ה' פעמים ומחצה ½], and it emerges from this, by the reckoning of the [volumes], that the sun is larger than the body of the earth by [numeral: 166 ≈ ? קס"ו] times and [numeral: ג' ? = three] eighths, and the body of the earth is larger than the body of the moon by [numeral: 39 = ל"ט] times, as stated. And it emerges from the reckoning of the [volumes] that the sun's globe holds more than the moon's globe by [numeral: ? שתת אלפים ות...ק ≈ six thousand five-hundred-odd] times and [a fraction], as was explained earlier at the end of maamar י"ד / י"ו [?] in siman [239] רל"ט — so then, how is it possible for the moon in its smallness to block the sun, so much larger than it?

The answer: were the spheres of the sun and the moon adjacent to one another, there would be room for this question... [text degraded] — but rather, because the small body of the moon is near, [while] the sun is high and far and distant from us up to the [sphere of Mercury], there is room to resolve the question. When you draw near to your eye a small thing, it prevents you from seeing a thing much larger than it. Know, then, that the earth [and the sun]... [degraded]... the moon cannot be interposed [truly opposite] in latitude as in longitude, and [therefore its eclipse] does not [obscure it entirely].

[Continuation of §228]

of any thing whatever, its darkening in itself would suffice for us; so too in [this] case: because the tilt of the moon's circuit from directly opposite the sun by the width of the firmament [is up to] [numeral: ע' ? — value uncertain]... it does not stand directly opposite the sun, but deviates from it in latitude either to the north or to the south, so on this account [at most months] it does not [block the sun] to the east or [to the west]. By [some] degrees the sun escapes the eclipse... so that no eclipse can happen to the sun except when [the moon] is at the head of the node or at its tail, or near them. Thus wrote the Israeli [R. Isaac Israeli] in maamar [numeral: ?] chapter [17] י"ז, that [the moon's] blocking of the width [is]... at the time of the molad, less than ten degrees and [numeral: 16 = ? ט"ז] regaim [the solar ecliptic limit ≈ 10°], whether before it or after it — otherwise the sun is not eclipsed.

סימן ר"ל [printed number worn — reads (230) ר"ל or possibly (229) רכ"ט; logical 231]

That the sun's eclipse is seen in one place in its entirety, in a second place [only] part of it, and in a third place nothing at all.

Already we explained that the moon's eclipse... since [the moon] is genuinely deficient in its body... it is therefore the same for all the inhabitants of the world, for in every place... where the eclipse is by night, and above the horizon, all the inhabitants of the earth will perceive and see it... the [moon's] eclipse is the same [for all]. But the sun's eclipse — at that same time its case is not so; for Reuven, Shimon, and Levi, who [dwell in different places] and see the sun at the [eighth] hour [numeral: ח' ? — hour uncertain], it happens that one of them will see the whole eclipse, another of them will see only part of it, and another of them will see nothing darkened at all, as you see in the figure.

Diagram. The solar-parallax construction. A large upper circle (the sun) bearing two point-letters at its top; two lines descend from it and cross, passing a dark disk (the moon) at their crossing; a smaller lower circle (the earth) carries observer-points. The three observers correspond to Reuven, Shimon, and Levi in the text.

- ד [dalet] (upper circle, left) and ז / ה [?] (upper circle, right): points on the sun
- (dark disk at the crossing of the lines): the moon
- ב [bet] (lower circle, top): observer's point on the earth
- א [alef] (lower circle, right) and ג [gimel] (lower circle, left): observer's points on the earth

Diagram. [Belongs with the shadow/eclipse discussion; printed at the top of the outer column of p. 134.] The earth's shadow-cone shown with the moon's disk set within it: two large circles with a dark hatched cone converging to a point at the left, and a small disk (the moon) inside the cone. Point-letters on the cone are worn.

- ד [dalet] (on the cone): legible
- (small disk within the cone): the moon entering the shadow
- Additional point-letters worn/illegible — [?]

סימן רל"א [printed §231; logical 232]

How much time falls between one eclipse and the next, and how many eclipses are possible in a single year.

Since a darkening of either of the two luminaries occurs only when [the moon] is at the head of the node or at its tail, or near them — the distance between the two "limits," that is, between the head of the node and its tail, corresponds to [half] the arc of the sun's orbital circle, and the time of the sun's revolution... is about half a year... — when the sun is eclipsed, it will not have a second eclipse until there have passed, from the time of the first eclipse, about six months at most, or five months at the least, sometimes [more] and sometimes less. Likewise the moon: since it revolves in its sphere over the distance between the head of the node and its tail before completing half [its cycle], in any case the moon will not come to stand opposite the sun at either of the two places except after the [interval] of the previous eclipse — about, as stated, five or six months. The reasons for the variation between one eclipse and the next are that sometimes the first eclipse occurs a known number of degrees before the head of the node and the second after the tail of the node, or the reverse; and also because in [each] of the two luminaries the motion [proceeds] at a slow, [even pace]... which is why differences of interval are found between one eclipse and the next.

And you should know that sometimes the sun is eclipsed in one month among the months, and after this in [another] month; and the reverse is likewise found — so that you should know it is possible for one year to include three eclipses of the moon: the moon eclipsed at the beginning of the year and eclipsed at the [end]... and in the same way it is possible for three eclipses of the sun to occur in a single year.

Such a thing already occurred in the year [**recte** 1589 ≈ [ט]פ"תק אלף — civil year; the earlier reading "חלק תכ"ט" was a misread of the worn glyphs, pinned by the paired AM on the same line] by their [civil] reckoning — that is, the year שמ"ט 349 = of the sixth thousand [5000 + 349 = 5349 AM = 1589 CE] — in which we counted three eclipses of the moon. These were:

- First [lunar]: 20 January [כ' יאנואר"י], which was [numeral: 15 = ? ו"ט] Shevat [? ט"ו שבט]
- Second [lunar]: 14 July [י"ד יולי], which was 15 Tammuz [(?) ט"ו תמוז] — astronomically expected (a lunar eclipse falls on the full moon, 15th) and consistent with the legible "14 July," but the ט"ו glyphs are not cleanly legible cold (Stage-5)]

- Third [lunar]: 9 January [ט' יאנואר"י], which was [numeral: 1 = ? 'א] Teves [א' טבת ?]

[the eclipses fell] within the compass of a single year. And the eclipses of the sun that occurred in the said year — these were:

- First [solar]: 6 February [ו' פיברואר"י], which was [numeral: 20 = ? 'כ] Adar [כ' אדר ?]
- Second [solar]: 30 July [ל' יולי], which was [numeral: 29 = ? כ"ט] Tammuz [כ"ט תמוז ?]
- Third [solar]: 26 December [כ"ו דיצעמבר], which was [numeral: ?] Teves [כ"ו/פ' טבת~ — day worn, [?]]

I give thanks to God, my Rock, my refuge and my deliverer, who helped me to the completion of the Ninth Gate. [אודה לאל צורי מחסי ומושיעי שעזרני בסיום שער התשיעי]

Gate Ten (השער העשירי)

In this gate I shall explain the motions of the five wandering planets — some in general terms and some in detail: the time in which the epicycle sphere completes its revolution by means of the carrying (deferent) spheres, and the time in which the planet itself revolves by means of the epicycle sphere; how at times some of the wandering planets are hidden beneath the light and rays of the sun; the period of revolution of each and every one of the planets; and other matters bearing on them.

Siman 232 (רל"ב) — Why the planets sometimes move forward, sometimes backward, and sometimes stand still

[printed 232 = רל"ב; logical siman 233]

Know that the astronomers have found and measured with their instruments that the five wandering planets sometimes move forward, sometimes move backward, and sometimes [remain] standing in place, going neither this way nor that. To grasp the cause and reason of these matters we shall explain them at some length.

[The figure] represents a portion [of an arc] of the mid-firmament [?], which is the sphere of the [fixed] stars; and beneath it, the form of the epicycle sphere, marked [ז ה ד (?)], whose center is point ז. And beneath that, at the [lower] tip of the drawing, is the likeness of the globe of the earth, whose center is point ח. Now

from the center of the earth, from point [ח (?)], two lines are drawn upward along arc א–ב [?], namely line [ח–א (?)] and line [ח–ב (?)], the two lines being tangent to the epicycle sphere on its two sides.

Now when one of the wandering planets stands at point ג or at point ד that we have drawn, it appears to us, as we observe it, as though the planet stood in the eighth firmament at point [מ (?)] or at point ב. For as we shift [our line of sight], the planet in its epicyclic motion appears to people as though it were fixed in the firmament at point מ, where the fixed stars are. Thus it will appear to you: when the planet revolves on its epicycle from west [to east], following the form of its center's revolution, and travels there from above along its course by way of [points ד–נ–ו (?)] toward our line of sight — while we stand below upon the globe of the earth at a point set before us — it is as though the planet moved in the eighth firmament from point ב to point א [?]. And when the planet's epicycle carries it back from below, [it appears to move in the opposite direction along the firmament,] so that it seems to us to travel [backward] — and this is the [apparent] retrograde motion — even though in reality [the planet itself continues forward on its own sphere], for it is only the appearance that reverses. So, too, when the planet is close [to the tangent points], it appears to go up along its course [near points ד נ ו (?)], to our line of sight, as we stand upon the globe of the earth, as though it went in the eighth firmament from point ב toward the west, [into the region of Aries (?)]; while at [another] point, it appears to travel eastward from point [ב] to point א.

[The geometric point-letters in this siman are printed small and are heavily worn; the readings marked (?) track the accompanying diagram but several individual letters could not be confirmed — see Diagrams field.]

Diagram. A retrograde-motion construction. An inverted triangle (apex downward) representing the visual cone from the observer, with a large circle (the epicycle carried on the deferent) set in the upper portion and a small circle at the lower apex (the observer / globe of the earth). Vertical Hebrew lettering along the right-hand slant reads **מאדים [Mars]**, indicating the planet illustrated. Readable labels (positions approximate):

- ב (top-left vertex)
- א (top-right vertex) [?]
- ג (upper center, on the triangle) [?]
- נ (on the central vertical line, above the large circle) [?]

- large circle (epicycle), across its horizontal diameter and center: ז … מ … ה (center) … ד [?]
- ח (below the large circle) [?]
- ח (in the small circle at the apex) [?]

— more than two labels uncertain.*

Siman 233 (רל"ג) — Why we see a planet remaining stationary in place, going neither this way nor that

[printed 233 = רל"ג; logical siman 234]

Now you can readily understand the reason for what is observed in the five wandering planets — that a planet appears to remain standing in its place, moving neither forward nor backward. For when the planet revolves on its epicycle, through the motion of the epicyclic sphere, to point מ, and travels along [line ד (?)], descending to point [ב (?)] in the figure, all this motion is drawn upward along the line of its course in accordance with its revolution [near the points]. Sometimes this lasts two or three days or more, since only a small [arc] of the epicycle [is subtended as seen] from the earth [near the tangent line]. For a stretch — [several (?)] days or more — the planet appears, from point מ up to point [ב/ד (?)], not to move at all to the eye, and as it travels on its epicycle it seems to stand still in its place. And the same holds when the planet reaches near point [ו (?)], close to point ד: it appears to us as though standing still in its place.

Siman 234 (רל"ד) — That all the planets are hidden beneath the sun's light, and the manner of their entering beneath its light and emerging from it

[printed 234 = רל"ד; logical siman 235]

It is already known that so long as the sun stands above the horizon, no star is visible to us, because of the overpowering, all-pervading light of the sun [which drowns them out], until the sun sinks beneath the horizon — and then, at once, the stars are revealed [and appear] from beneath its light, growing large and visible. Nevertheless, the stars that lie close to the body of the sun are not seen immediately after the sun sets, because the sun's rays are still near them, until the sun has withdrawn — after a known number of days — as it revolves and its place grows more distant [from them]. And this holds for each and every one of the wandering planets.

[Likewise for the reckoning of the planets' emergence from concealment beneath the sun's light: the rule for them] is the same as for the moon after it has been hidden beneath the sun's light [at conjunction], as was explained to you above in the Eighth Gate, siman [239 / רל"ט (?)]. It remains for us to explain a little concerning the concealment [beneath the sun's light] of the other five wandering planets. There is a great difference among them — both as regards the [manner of] their descent beneath the sun's light [i.e. heliacal setting] and as regards the emergence of the other wandering planets from beneath its light [heliacal rising]. This [difference] arises from the great size [of the epicycle] and from the nearness of each one [to the sun] — whether the planet is at its apogee or opposite [its epicyclic position] — [which produces] the disparity among the [visibility] intervals when the planet revolves [on its epicycle]. [The intervals differ] because at the setting of the sun some [planets] lie near [the horizon] and some far, and their distance from the sun differs; so, too, some are hidden [in the sun's rays] for a longer time, some for a shorter — for days [and weeks (?)]. And their causes are one and the same: it is fitting to know that from the time the epicycle sphere begins [its motion], the planet [whose] center [rides on the deferent (?)] revolves beneath the center of the sun, [and] its distance [from the sun determines its visibility].

Siman 235 (רל"ה) — How Venus is sometimes seen before the sun and sometimes after it, and sometimes is not seen at all

[printed 235 = רל"ה; logical siman 236]

The planet Venus [כוכב נוגה] has many variations and rules that must obtain regarding the times of its rising and setting [as morning or evening star]. For sometimes this planet goes before the sun and rises above the horizon before it, in the morning, ahead of sunrise; and it is then called the **morning star** — in Hebrew, [it is called *Ben Shachar*, "son of the dawn" (?)] — and the commentators explained it thus as the "star of the morning." And sometimes this planet goes behind the sun and sets after sunset in the west, and it is then called the **evening star** or the **twilight star** (*kochav ha-neshef*). These two [phenomena are one and the same planet] — and they are not two separate stars, as the foolish suppose.

Sometimes this planet is seen after sunset only for a short while [above the horizon]; and sometimes it remains above the horizon [for] an hour or two — at times increasing, at times decreasing. And likewise in the morning, at its rising upon the eastern horizon: sometimes it precedes the sun's rising by only a short time, and sometimes by an hour or two. Sometimes it draws very near the sun,

and sometimes this planet is not seen at all, neither morning nor evening, because it is hidden beneath the sun's light for as long a time [as it remains near it].

To make these matters, which are obscure, clear to you: when Venus is on its epicycle, its body at point ד of the drawing — at the farthest point from the sun — it [is seen] large [and bright]; [and its center, together with the centers of all the wandering planets, is always aligned toward the center of the sun]. There are [therefore] four centers upon one common line: [the earth, the epicycle-center, the planet, and the sun (?)]. When the sun is [rising], [the planet's visibility follows accordingly]. And when the aforementioned planet reaches point ה [or ד (?)] of its drawing, near [conjunction], it becomes hidden and revealed [in turn], and it appears [again] daily [as the sun withdraws].

Diagram. Two concentric circles (the carrying/deferent sphere) with a small circle (the epicycle) set at the top, illustrating the epicyclic motion of Venus (or Mercury). Caption beneath the figure: **כמשל [kimashal, "by way of example / as a model"]**. Readable labels (positions approximate):

- ג (at the top, above the small circle) [?]
- small circle (epicycle): ז … ד … פה [?]
- ח (just below the small circle) [?]

— more than two labels uncertain.*

Siman 236 (רל"ו) — That the planet Mercury too behaves like Venus, and that one and the same rule and law applies to both

[printed 236 = רל"ו; logical siman 237]

Know that the center of Mercury's epicycle sphere is likewise forever fixed beneath the center of the sun [i.e. it moves with the sun's mean motion], just as [Venus's is]. And [as for] the time of the revolution of the center of its epicycle: it circuits [the zodiac in the same period as the sun (?)], just as [with Venus]. And the time of the revolution of Mercury's own body on its epicycle sphere, and [the reckoning of] their conjunction and its recurrence — all this is [given below]. [Its greatest elongation from the sun (?)] is some [23 / כ"ג (?)] degrees, [and thus it is more difficult to observe than Venus (?)].

Mercury too, then, behaves after the manner of Venus: [its visibility depends] on the sun's setting [and rising]. [It is hidden and revealed] at the recurring

[conjunctions], according to all the reckonings and rules — the variations and particulars — [set out] for the [wandering] planets, [in the same way] as [Venus]. As you shall know [about] this planet: it is not [seen at all when it is hidden beneath the sun's light]. And so also for the rest of the wandering planets.

Siman 237 (רל"ז) — [On] whether — and how and in what manner — the three upper planets, namely Saturn, Jupiter, and Mars [שצ"ם], are [concealed] beneath the light of the sun

[printed 237 = רל"ז; logical siman 238]

[If one should set about] to explain the particulars of its matter [i.e. how each of the upper planets is hidden]: [as regards] all [these (?)] wandering planets — [the point at which each sinks beneath the sun's light and emerges again] — [the same principles apply]. [The three upper planets, being far above the sun, are hidden only when they come into conjunction with it, and each is again seen when the sun has withdrawn from it by the requisite arc.]

[This siman is set in worn small type at the foot of the right column of p. 139; the opening geometric detail could be read only in part — several clauses are flagged, and the interior specifics are given below only as far as legible. Marked as a degraded region /]

Siman 238 (רל"ח) — Whether the light of the planets is from themselves, or whether it is acquired by them from the light of the sun

[printed 238 = רל"ח; logical siman 239]

The [question of] light — as it is found in the planet [Venus (?)], and likewise in all the [other] planets: some say [וי"א] that their light is their own, from themselves, like the sun; and some say [וי"א] that the light of all of them is acquired, and that they receive their light from the light of the sun, as does the moon. And [one might argue] that no star [could be self-luminous] — [therefore] they must stand [receiving light from the sun], for [otherwise (?)]…

[The sun,] when the globe of the earth comes between it and the [planet], is [eclipsed]; the small shadow [cast by the earth (?)] — thus it appears [that the planet is darkened]. And [although] it is not incumbent upon us to inquire into the reason [of every such matter], [we note that] the globe of the earth [stands] at the midst of the sphere [as before, as was set out in the first (?)]. [Whether the

planets shine by their own light or by the sun's, the phenomena of their appearing and disappearing are as described.]

[The two-opinion discussion is legible in outline but individual supporting clauses at the column foot (p. 139) and column head (p. 140) are worn; readings marked (?).]

Siman 239 (רל"ט) — How large the body of each of the [seven (?)] wandering planets is, relative to the body of the globe of the earth

[printed 239 = רל"ט; logical siman 240]

Know that the astronomers estimated the diameter of each one of [them], [comparing (?)] the planets and measuring them against the measure and diameter of the two great luminaries [the sun and moon]. [Ptolemy (?)] and later scholars explained this. As to the body [size] of the planets, the ancient astronomers reckoned the size and diameter of the body of [the (?)] planet [Saturn]: the diameter of the body of Saturn is close to [some given multiple of] the diameter of the sun [?], and [Saturn's body] is nearly [as large], [being some number of times (?)] the [earth]. And its body [is greater than the earth (?)] by [/ כ' 6 (?)] times.

[The bodies of the several planets, relative to the earth, are given approximately as follows — the multiples themselves are printed in worn type and several are flagged:]

- Saturn: [its body] greater than the earth's by [numeral: ?] times.
- [The remaining ratios in this passage are printed small and worn; the specific multiples for Jupiter, Mars, and the rest could not be read with confidence — [numeral: ?] — and are not committed here.]

[This siman gives numeric body-size ratios throughout; the numerals are in small worn type and are largely illegible on the scan, even under magnification. No values are invented.]

Siman 240 (ר"מ) — A table of the periods in which the carrying sphere and the epicycle sphere of each of the [seven (?)] wandering planets revolve about the globe of the world

[printed 240 = ר"מ; logical siman 241]

The times in which each one of the [seven (?)] planets carries the center of its epicycle sphere — by means of the carrying (deferent) sphere — around the globe of the world, according to their [sphere-]motion from west to east, are as follows (all in close reckoning):

Table A — Period of the deferent (epicycle-center around the zodiac). *(Table reads right-to-left in the source; the planet rows run down the right column, Saturn through the Sun, and continue at the head of the left column, Venus through the Moon.)*

Planet	Full circuit of the zodiac	Per sign
שבתאי (Saturn)	about 30 years	each sign ~2½ years [כ"ב שנים וקצת (?)]
צדק (Jupiter)	about 12 years	each sign one year
מאדים (Mars)	two and a half years [שתי שנים ומחצה] *(see Numerical impossibles)*	each sign ~2 months [and a little]
חמה (Sun)	about 365¼ days [כשס"ה יום ורביע]	each sign one month
נוגה (Venus)	likewise about 365¼ days	each sign one month [?]
כוכב (Mercury)	likewise about 365¼ days	each sign one month [?]
לבנה (Moon)	27 days, [7 (?)] hours and a half	each sign [numeral: ?]

The time between one [lunar] conjunction and the next is 29 [days], 12 [hours], [and 793 chalakim (?)], as was set out above in siman [204] ר"ד.

And the time in which each of the planets revolves in its own body on its epicycle sphere is this: *(a second set of period values follows for the planets' own epicyclic revolution — Saturn [numeral: ?], … Mercury the lesser [כוכב קטן] [numeral: ?] days [numeral: ?] hours; for the Moon, 27 days [13 (?)] hours). These epicyclic-period figures are in small worn type and are largely illegible; [numeral: ?] — not committed.*

A most precise calculation, by means of [observation] — namely, the period of revolution of the center of the moon's epicycle about the globe of the world, and the period of revolution of the moon's own body on its epicycle, and the length of the lunar month — as I received it from, and from the reckoning of, **[Johannes — surname illegible on the scan, not identified]**, chief of the astronomers before the **Elector (Kurfürst) of Brandenburg** [הקורפירסט … ברנדינבורג] (the

"Brandenburg court astronomer" is a *title* — Kurfürst/Elector — not the man's name):

- The revolution of the center of the moon's epicycle by means of the carrying sphere is **27 days, 7 hours, [4 (?)]0 minutes**; each day [it moves — the source expresses this as **2¼ days per sign (≈13°20′/day)**; the precise "13°10′34″" is a conversion/reading not confirmed on the scan under magnification, flagged: 13°10′34″ [?]], [103 (?)] thirds [שלישים].
- **The length of the lunar month**, from one conjunction to the next, according to the mean motion, is **29 days, 12 hours, 44 minutes, [50 (?)] seconds** [and a further fraction].

[The two lunar values above are recognizable classical figures; the individual sub-units marked (?) are worn in the print. The court-astronomer's name is garbled by the compositor and is flagged — see Glossary candidates.]

Siman 241 (רמ"א) — How far the [seven (?)] wandering planets deviate from the mid-line of the firmament — the line of the zodiac — in the breadth of the sky, toward the north and toward the south [i.e. planetary latitude]

[printed 241 = רמ"א; logical siman 242]

We have already explained above, in siman [קפ"ה (?)] and siman [קנ"ג (?)], that the plane of the zodiacal belt of each of the five wandering planets is inclined away from the great circle [of the ecliptic (?)] that stands [along] the line of the zodiac; part of it [tilts] toward the north and part toward the south. [The angle by which each planet's orbit tilts north or south of the ecliptic determines its "breadth" — its latitude.] When [a planet stands as far] toward the north or toward the south [as its orbit permits], it is said of that planet that it stands "in the breadth of the firmament," and the measure of that distance, or the deviation, of each and every wandering planet from the line of the zodiac to the north — and likewise to the south — [is given below,] as I received it from the scholars, [foremost among them Johannes … / קצעלי״רוס (?) — name garbled, ?].

Table B — Greatest latitude (deviation north/south of the ecliptic). *(Table reads right-to-left in the source.)*

Body	Greatest latitude
שבתאי (Saturn)	three degrees

Body	Greatest latitude
צדק (Jupiter)	half a degree, up to a third of a degree [?]
מאדים (Mars)	three and a half degrees; for the most part there is a difference between [its] north [and south]
חמה (Sun)	it has no breadth at all, for it is always in the plane of the world, beneath the line of the zodiac
נוגה (Venus)	more than all of them, some nine degrees to the north, and likewise to the south
כוכב (Mercury)	three degrees
לבנה (Moon)	five degrees and a quarter

With the help of the Helper — on the day of trouble — we have completed ten gates. [בעזר העזרה אותו ביום צרה — השלמנו שערים עשרה • a rhymed colophon closing Gate Ten.]

The Eleventh Gate (השער האחר עשר)

[Gate 11 opens here, at the head / folio (70) ע recto.]

In this gate will be explained the construction of a sighting instrument called the **quadrant** (כלי רובע, *kli rova*), with which one measures and determines, in every location: the altitude of the pole [the celestial axis]; likewise the altitude of the sun, and of every other star among the stars of heaven — how high it stands above the horizon; the position of the sun among the zodiacal signs on every day of the year; also the time of the sun's rising and setting, and the difference in the lengths of days and nights in every place throughout all the days of the year — together with many other matters besides these.

Siman רמ"ב [printed 242 = logical 243]

On a sighting instrument called the quadrant — to learn the method of [measuring] the altitude of the pole and the altitude of the stars.

The author says: I saw fit to teach the students, in this gate, the science of measuring the stars and the [celestial] degrees by means of a sighting instrument (כלי מחזה) made in circular form by the hands of the scholars of astronomy. Their sighting instruments are many, of various kinds; but the most pleasing [choice]

for the body of the instrument is the one whose shape you find to be a quarter of a complete circle. On account of this it is called *kli [k']dun-rova* [?] and in the Latin tongue **(קוואדראנט, quadrant)**, that is, "the quarter-part of a circle."

And I, the author, wished [?] to give this instrument a name by way of borrowing from the language of Scripture — from the word *chanoch* [חנך, "train/dedicate"], as in [the verse] "*Train up a child in the way he should go*" (Mishlei 22:6) [reading uncertain; the Scriptural play is on the root חנך]. [?several words illegible?]

All the commentators [describe] the surface of the instrument [with?] a plumb-line [קו] of lead like a weight [כמשקלות], which serves to straighten a wall or a building, and likewise for other matters of measurement — such as measuring [?] the mountains, the vineyards, and the distances [?] of the roads of the countries; for all this the scholars of measurement use the instrument with plumb-weights. We have already explained this at length in the book we composed, "[Ha]Prozdor" [?title uncertain], and this is not the place for it.

But here our intention [in naming it] is to explain this instrument to beginning students [?]. By means of this instrument the student will come to know the altitude of the sun, and clearly [the altitude of] all the stars of heaven whose [height] he wishes to know, in every place and at every time; also the position of the sun among the zodiacal signs on each day throughout all the days of the year; also the hours of the day, together with a treasury of many features peculiar to it, as will follow.

For just as the sphere of the zodiac makes a complete circle of **360 [ש"ס]** degrees, so too the measurements we teach with this instrument [are done] on a quarter of the circle [= 90°].

Because the sphere of the [zodiac] in its entirety — which is already divided into 360 degrees — is not all seen and revealed to us above the horizon, but only a count of **180 [ק"פ]** degrees [i.e. half]; for its [other] half is a portion [כח] hidden below the horizon, beneath the earth. And even of the visible half that is above our horizon, the observer cannot see [all of it] at once [?]... toward the four directions of the world [only?] half of them, which are **90** degrees.

And you must know that, since this instrument is only a quarter-part [?] of a circle, [when you consider] the whole angle in a complete circle, the instrument's [apex] stands at the point at the center [?] of the complete circle; and because of the corner-angle mentioned, it is called the **center (מרכז, merkaz)** of the instrument.

Moreover, you must know that whatever is found [measured] by means of any sighting instrument [is found thus]: bring the instrument close to your line of sight, raise your eyes, and sight along the edge of the instrument in a straight line toward the point of the place whose altitude — or whose distance [?] — you wish to know; and then it is as though the very line [edge] of the instrument were extended in length until it reaches, in a circle [?], the point that you seek.

Diagram. A plain circle with an inscribed quarter marked off by two perpendicular radii meeting at the center and a connecting arc — illustrating the definition just given, that the quadrant is a quarter (רביע) of a complete circle. No point-letters or numerals appear on this figure.

Siman רמ"ג [printed 243 = logical 244]

That the quadrant instrument is [constructed] upon [the base] ב-[מ]-א [?] … in the first method (הבחינה הראשונה). [Heading partly garbled; the sense is that this siman treats the "first method" (בריח המורה, the sighting-alidade) construction.]

Know that the making and setting-up of the quadrant of which we speak is done in [two] ways [?]: the first by means of the **sighting-rule (בריח המורה, the alidade)**, the second by the **plumb-rod (מוט המשקל)**. We shall choose to begin with the method that uses the sighting-alidade, and this is how you make it.

Make yourself [an instrument] of some material — a board [דף], one [side] — whose overall shape is a quarter of the complete circle, as above; [call the figure] א-ב-ג and ד [?]. The left side of the instrument is this edge [?]; the upper line, call it ג [?]; and the right side, which is [the edge] ד [?] — [call it thus]; its base, call it א ב–; and its arc, call it [ב–ד] [several letter-labels uncertain].

This arc you divide into **90 [צ']** parts, which are called degrees. And this division — [set up] so that it be taught to the students in a straightforward way — [proceeds thus]: first divide the whole arc into three parts; each of the three parts divide again into three, yielding nine parts; each of which [you divide further] [?] so that the sum of all the parts is **90 [ninety]**, each of which represents [?] degrees. Mark them on the arc by number, from below upward, up to 90 [reading of the terminal numeral uncertain]. And to complete the ninety, [with a] space [?] between each mark, rule them with fine strokes [?], each [degree] into five parts; so that all the parts are ninety, and they are called degrees; and these ninety degrees are a quarter of the 360 degrees of the sphere, as in all [such instruments].

**

[Siman רמ"ג continues at the top of the next page.]

Take a rule [the alidade] [?] whose length is the diagonal of the instrument and whose width is half [its diagonal?] [?]; [such a rule is called...] [?several garbled words?]. This alidade [בריח] you attach at one end to the center of the instrument, at point א, and let the joint-pin be like an **axle (ציר)**, so that you can rotate it and move the alidade across the whole face of the instrument.

On this alidade, on one side, attach two small **rings (טבעות)** facing one another [reading of "facing one another" uncertain], with [?] two fine **holes (נקבים דקים)** — each of them like a small perforation — so that the two holes are aligned one directly opposite the other; and let the two holes be [set] on [the back of?] the alidade itself, or a little raised above [it], at an equal height [?]. These perforations that we mentioned are called [כור"ל / ?] — [term illegible] — [and thereby the instrument is] properly fashioned, and measurement by it is obtained [?].

As for the dimension of the center [?] and the width of this instrument: it has no fixed or set measure; but the larger the instrument, the greater the precision of measurement. Know that the measure customarily set before the scholars of the science is about a **quarter of an amah** [cubit] by a quarter of an amah in width; [and] I have another instrument that holds **half an amah** in length by half an amah in width.

Siman רמ"ד [printed 244 = logical 245]

How measurement is done with the quadrant instrument.

Now that the quadrant described above, made with the aforementioned alidade, is properly fashioned, I will show you how [to measure] [?] the altitude of any star.

The [point] at which the sun or the star comes to rest [?] — that is called the **altitude of the sun** or of the star. To know how many degrees a given star stands above the horizon: set it up — for example, upon a table — in an upright position, level [ישר] to the horizon, without any tilt to the sides; and aim the two edges of the instrument [so that its face looks?] downward [?]... at angle ג / point ה [?] of the instrument [reading uncertain]. The observer sets its face aligned against the point of the star at [his] zenith [קדקד].

And when you sight some one of the stars, raise [the instrument], set [your eye?] to the center of the instrument, which is point א, and turn the alidade toward it

[לנוכח], and wait until you can see — over the alidade, through the two holes — the star whose altitude you wish to know.

[The measurement] begins with the alidade at some part of the number [-scale]; [there] you will find [?] the number of the altitude that you sought to know. And this matter is always [?] so, [and] it is necessary to premise it, for it is plain and evident to the eyes of all: because the arc [90-ל?] on which the degrees are marked is set aligned against the arc [?]... from the [point] nearest [?] up to the point opposite the zenith. It has already been explained that its arc [shows] for each and every degree [?] the number of the arc [being] aligned [?]... [several clauses garbled]... through the sighting-alidade, by way of the perforations, and the sighting along the alidade — for example, up to the degree [?] at the larger part of the number-arc; and this same aiming proceeds and touches [?] the large [division], which is also at the aforesaid sixth [?] degree. And all the matters mentioned you will see in a figure such as this:

Diagram. A quarter-circle (quadrant) instrument shown with its graduated arc and shadow-scale. The curved outer band carries a degree scale numbered by fives — legible values include **5, 10, 15, 20, 25, 30, 35, 40** and continuing toward **90** along the arc. An inner shadow-square scale runs along the straight edge, with the small values **5, 10, 15, 20** [and further, partly illegible] marked in the boxed cells. Two small squares set along one straight edge represent the sight-vanes (pinnules / נקבים). The corner point-letters of this figure are not legibly recoverable on the scan, even under magnification. [Interior numeric cells and corner labels illegible.]

Siman רמ"ה [printed 245 = logical 246]

Everything that lies on the line of the ray [line of sight], even though the one be larger than the other — even by a thousand parsah — is reckoned as a single altitude for both of them.

Know that the ray [line of sight] goes out from the eye and reaches the sphere of the stars. Everything that lies on this line — whether near or far — is reckoned to them all as one altitude, even though the one is higher above the earth [?] by a thousand [אלף] parsah [than the other]. Whatever lies along the line of the ray that constitutes one altitude is reckoned as one for all of them.

By way of example: a certain window [חלון] [?] — its top, [call it] point [א], [lies] opposite our eye at only 20 [?] degrees [reading of the value uncertain]... and against it [is] point [ד] [?], by means of the sighting instrument, [at] **fifty (חמשים)**

degrees [?]. And the whole [line] rolls on [?] from the [point of the] eye up to the points [?] — up to some one star [ה'] of the stars of the eighth sphere; and the altitude of that star, though it be higher [above the air / the earth] by a thousand [?] parsah [reading garbled], is by this construction [reckoned the same as] the top of the window. [Geometric example heavily garbled by the compositor; point-letters and several numerals uncertain.]

And two stars found [on] one [line] in this construction — each of them [at] [?] degrees — [have the same measured altitude]; only, the degrees of the point at the top of the window are small and short degrees [i.e. a small arc-length], whereas the degrees [reaching] to the star are large and wide [reading uncertain].

And know that all we have said [with these examples?] we set out at length as a parable and analogy for the quadrant made according to the **first method**, that is, by the sighting-alidade. And now hear the rule and law of the quadrant made according to the **second method** — [that of] the plumb-weights [המשקלות] — whose plain, direct way has already been explained to you above; so, just as [in] the second gate [?], let us now add its rule for the second [method] as well, with [almost?] new points.

Siman רמ"ו [printed 246 = logical 247]

The nature of the making and construction of the quadrant instrument according to the second method.

The author says: since [the matter] was mentioned at length above — [in] Gate [ב?], siman כ"ח and כ"ב [28 and 22 — cross-reference as printed; both siman numbers uncertain] — [namely] the nature and construction of the quadrant according to this [second] method in circular form [?]; and since the whole content of this gate is pressing [me] to teach the students the essence and purpose of the way of measuring the stars and the zodiacal signs — therefore, by [what may be] an oversight of my hand [?], I saw fit to write it here a second time, more fully [ביתרון], with points that are new and wondrous. And this is how you make it:

From a material — a board [דף], one [side] — whose overall shape is to be a quarter of the circle, as above, which we call **א-ב-ג**; and again [take] point **א**, and go to its left [side] **א–ב** and the right [side] **א–ג**, and its arc **ב–ד** [reading of letter-labels partly uncertain]; whose figure is likewise [set up like the first]. [Here the

two methods are compared:] the [difference] is great [?] — this being the **first method** [with the alidade], and the second method by means of [the plumb]...

** From the center of the instrument, which is point **א**, [also] draw one line — a little longer than the diagonal of the instrument — [set out] in the figure [as...]; and this line is called the **plumb-line (קו המשקל)**, since from it will hang a small **lead weight (משקל קטן מעופרת)**, in order to draw down and keep straight the hanging of the thread downward.

Fasten well to the thread a **bead/pearl (מרגלית)** or a small [weight]; fix it on the thread [by passing it] through the hole of the bead, so that it [hangs] on the thread — the plumb-line — down below [?]. [Then along the edge] [?] make two small [projections / plates] and bore in each of them a small hole, in such a way that the two holes lie on one straight line, aligned one against the other, by the method already explained to you above, as [stated] nearby; and these two holes [serve] according to the second method, and [thereby it will] be given to you to know [the altitude].

For, according to the rule: the difference is that the first method [works] by sighting with the eyes [?]... [some words garbled]; in the [two] methods: in the first, the arc faces [one way] [?], and in the second, the center faces upward. Nevertheless know that the two are in agreement, like neighbors, having one root and one foundation; and although the [two] methods are two, they are both as one and have one intention. Even so, most of their [the instrument's] operations here [will be treated] according to the **second method**, because it is easier — and larger — and it spares the instrument the trouble of setting it level to the horizon.

Siman רמ"ז [printed 247 = logical 248]

The forms and figures of the quadrant instrument, with all its rules and regulations.

I — before I begin to speak of presenting the figures of the instrument — [say] this: because it is difficult, indeed impossible, to fully [convey] and [make] the students understand [reading of "and half the building/matter" uncertain] the rules of this instrument and its operation without a figure and many forms — and, in order not to multiply figures for each and every lesson — I saw fit to present before you, at the very outset, all at once, the entire figure and form of the instrument as needed for this [purpose] in this gate, from which every person of understanding may discern and grasp all the rules of the instrument,

according to what will be explained [in siman ו"רמ/? — cross-reference numeral uncertain].

Diagram. A large square-framed **quadrant instrument** occupying the upper portion of the page, drawn with a full grid of concentric arcs and radial lines (an *quadrans vetus* / shadow-square type). Readable elements:

- **א** — top-right corner of the frame (the apex/sight edge).
- **ב** — top-left corner of the frame.
- **ד** — bottom-left corner of the frame.
- Bottom-right corner label — present but not legibly read [ג?] [?].
- **ה** — an interior point-letter in the upper field of the grid.
- A small interior mark near a circle/disk at center (the sighting-point or plumb origin); its letter is not legibly recoverable [?].
- Two small **squares** set along the right straight edge represent the **sight-vanes (נקבים / pinnules)**.
- **צל ישר** ("straight shadow" — *umbra recta*) — labeled along the lower diagonal (the shadow scale).
- **צל הפוך** ("inverted shadow" — *umbra versa*) — labeled along the upper diagonal.
- Zodiac-sign names run in one of the curved calendar bands; legible signs include **טלה** (Aries), **שור** (Taurus), **דגים** (Pisces), and **דלי** (Aquarius); adjacent band-words include **עגול**, **שעות** ("hours"), **מעלות** ("degrees"), and **מחצות/דמחצות** [reading uncertain].
- Degree numbers run along the outer arc (by fives) and along the right edge; legible values include **16, 28, 40, 60, 90, 88, 80** [several numerals reversed/mirror-set in the print and uncertain], and inner series **5, 8, 4, 7, 9, 10, 12** and the like.

[More than two labels/numerals in this figure are uncertain — figure is a]

Siman רמ"ח [printed 248 = logical 249]

To find the altitude of the sun — how high it is above the horizon.

We have already explained above that the astronomers [התוכניים] give the name "the altitude of the sun" to every place at which the sun [stands] — that is, its brightness [נוגה] above the horizon; and [we explained] the degrees, by means of this quadrant, [showing] how high a given star stands above the horizon.

Take the quadrant in your hand, at the side **א–ג** of the instrument — the one side that has the sight-holes — and aim the two sight-holes [?], [holding the instrument] upright [נצב] [?], toward the [celestial] bodies [הגרמים], aligning [them] in such a way [?] as explained above. Place [the instrument] near the pupil of your eye and look and sight along the edge of the instrument, through the perforation [?] of [point] ג [?], by way of point **א**. Raise and lower the center of the instrument — which is point **א** — up and down, until you see, through the sight-holes, the sun (or whatever other star) whose altitude you wish to know; and once you have caught it [?], hold [the instrument] firm, and look below on the numbered arc [to see] how many degrees the plumb-line [קו המשקל] cuts there — those are the numbers of the degrees of the altitude you sought to know.

And as for measuring the sun: since it is impossible for a person to look through the sight-holes straight against the disk [גלגל] of the sun, therefore know that you need not look with the pupil of your eye at the sun [directly], but only...

[Siman רמ"ח continues beyond this page.]

שער י"א (Gate 11) — the quadrant, instruments, and surveying (continued)

סימן רמ"ח (printed §248; logical §249) — [continuation: finding the sun's altitude with the quadrant]

you need only raise and lower the center of the instrument until the sun facing [the sights] passes through the two observation sight-holes [נקבי ההבטה]. Then look below at how many degrees the plumb-line (קו המשקל) cuts [on the graduated arc], and so forth — and that is the number of degrees of the sun's altitude (גובה השמש).

סימן רמ"ט (printed §249; logical §250) — that the determination of the stars' altitude is done in one of three ways

You should know that determining the altitude of the sun or of the other stars is done in one of three ways. The first: how high it stands above the southern horizon when it reaches the meridian [קו חצי יומם], and this is the chief object of precision [?]; [it serves] the investigation of the positions of the stars [מעמדי הכוכבים], and by this examination the astronomers scrutinize the motion and position [?] of a star. The second, likewise: how many degrees each star stands above the horizon — whether the western, the northern, or the eastern horizon. And the third: how many degrees the sun, or any of the other stars, gains in

altitude at any moment as it revolves between the [eastern] horizon and the meridian, and likewise in its descent — how many degrees it [descends] as it revolves between the eastern horizon and the meridian [and the western horizon] [?]. This [third case] requires more precision than the first two, and further [detail will be added] as it is described [below], God willing [?].

סימן ר"ן (printed §250; logical §251) — to find how many [degrees] the northern pole [ציר הצפוני] rises above your horizon, in every place and every time

Finding [the altitude of] the northern pole is a matter of great and general importance, much needed — the cornerstone [אבן הפינה] [?] of the science of the stars and constellations, and [essential] for knowing all the places and boundaries of the terrestrial globe, of benefit to others [?]. I saw fit to set down in my book, in this place, the matter of finding it by four straight and pleasant methods.

The first method I have already disclosed, and we explained its procedure clearly above, at the end of the Second Gate, siman (53§) נ"ג. But so that all four methods be found together, I saw fit to write this one a second time here as well. And this is how it is done:

Take, at the beginning of the revolution of a star, one of the stars that never set below your horizon — these being the stars near the northern pole [הסמוכים לקוטב הצפוני] — [to determine] the altitude of the pole above your horizon, or the [angular distance by which] your zenith [קדקדך] is distant [from it] [?], as [explained] above, siman [?]. Observe [ותשב] one of the recognizable stars [when it stands] to the east of the meridian line; and when the star revolves by way of the west and reaches the meridian [קו חצי יומם], where its altitude above the horizon is greatest, then measure with the quadrant how many degrees its altitude is above your horizon, and keep this number.

After some 12 [?] hours, when the star has revolved another revolution and reaches the meridian a second time — where it is now at its lowest [בתכלית שפלותו] — measure its altitude above the horizon likewise, and keep that number too. And half [מחצה] of [the sum of] the two kept numbers is the number of degrees of the pole's altitude above the horizon. An example of this: at its greatest altitude you found it 70° [ע' מעלות] above the horizon, and at its lowest 30° [ל' מעלות]; then the sum of the two numbers is 100° [ק' מעלות], [and its half, 50°, is the pole's altitude] [?].

סימן רנ"א (printed §251; logical §252) — another way to find the pole's altitude in every place — and it is quicker and easier

Take a star whose distance from the northern pole [מרחקו מציר הצפוני] is already known to you; take specifically one of the stars that never set below your horizon, as above. If the star you choose is found to the east of the meridian, keep [watching] it until [it reaches] the meridian, [and there] it is at its greatest altitude; measure how many degrees the star stands above the horizon, and subtract [?] its northern distance from [the number of] its altitude. And if the said star is found to the west of the meridian, keep [watching] likewise for its arrival at the meridian, where it is at its lowest; [there] add the number of its altitude to the number of its northern distance, and the result is what is sought.

An example of this: a star whose distance from the pole is already known to us — say the star [name uncertain: בעל עגיל" / "הכתלי"ן [?], mentioned above, siman כ"ד (24§)] — its distance from the pole being [about 30 (or 33) [?] degrees and 53 [?] minutes] — and we found its light to the east of the meridian. Here in the city of Prague [עיר פראג], at its arrival at the meridian, where it was at its greatest altitude, we found it above the horizon [71°32' — ע"א מעלות ל"ב דקין [?]; there remains for us [50°6' — נ' מעלות ו' דקין [?] as the [pole-altitude] number. [At its lower culmination we found it likewise [some value [?]] degrees above the horizon; adding gives the same figure.]

סימן רנ"ב (printed §252; logical §253) — to find the altitude of the northern pole in the daytime, by the course of the sun on the days of the Nisan and Tishrei equinoxes [תקופת ניסן ותשרי], in every place, whether at sea or on land

On the day the sun enters — not [merely near] the equinoctial point [נקודת היושר], that is, but [exactly] at the beginning of the sign Aries [מזל טלה] or the beginning of the sign Libra [מזל מאזניים], which are the two days of the true equinoxes [תקופות השלמיות] — determine at midday how many degrees the center of the sun stands above the southern horizon; that [altitude] is at present [the sun's meridian altitude]. [Then subtract it from 90°, and] the complement to 90° [תשלום צ'] is the number of degrees of the northern pole's altitude above the horizon.

An example of this: here in the city of Prague [פראג], on the day [of the equinox] I found the sun above the southern horizon at [39°(?) — printed "ל"מ" [?]] degrees and [24 (or 36) [?]] minutes. Add [it] to make up 90°; the addition [i.e. the

complement] is 50° 24' [חמשים מעלות כ"ד דקין] [?] — and so is the number of degrees of the altitude of the northern pole [above the horizon at Prague].

סימן רנ"ג (printed §253; logical §254) — to find the altitude of the [northern] pole in every place, by the course of the sun on each and every day of the year

Should you wish to know from it [the sun] the pole's altitude, take the meridian [midday] altitude of the sun on some one day, and consult the table [luach] to see the sun's distance [from the equator] — [its declination] on that day, and whether it is [north or south] [?]. [Adjust the meridian altitude by the declination:] if the sun is [then] in the southern signs [במזלות הדרומיים], [add] the number of its distance [i.e. declination] [to the co-altitude] [?]; and if it is in the northern signs, [subtract] it. [Working the sun back to the equator this way yields the equinoctial altitude, from which the pole's altitude follows as in the previous siman.]

And you should also know that this reckoning holds by way of [both] the mentioned known [stars] and [the sun] [?] — [these being valid] according to the astronomers, on the authority of the [observers] [?].

סימן רנ"ד (printed §254; logical §255) — that every observing instrument, in every place, must be set [according to] the pole-altitude [of that place]

Know that all the measurements and devices that will be explained [below] to the wise are, in [their proper] time, [performed] with the quadrant instrument [כלי הרובע] — sufficient for all who share the same latitude [רוחב] of the world, that is, all who dwell on one [parallel] line. But in every place, from north to south, each and every one of them needs an instrument specific to the pole-altitude that obtains there. Therefore know that this whole quadrant instrument depicted [in the figure] above is made according to the pole-altitude that obtains here — [namely] at Prague [פראג], [where the pole is] above our horizon 50° 6' [נ' מעלות ו' דקין] [?]; and further, according to the [local latitude elsewhere it must be re-made].

[Know further:] when there comes into your hand an instrument like this — one such as you have never before seen — you will be able, from its very form, to determine and verify to what pole-altitude it was made [?].

סימן רנ"ה (printed §255; logical §256) — to inscribe on the face of the instrument three principal arcs: one [middle, for] the equator [Aries–Libra], one for Capricorn, and one for [Cancer] — and how much the sun's altitude is on each of them

Divide [?] [the graduated edge]. [The instrument's] arc-of-number [קשת המספר] runs from [0°?] to 90° in equal degrees [?], as [explained] above; and now measure [and mark] on the [instrument's] center: the arc (66) ס"ו [?] is for the circle of Capricorn [עגול גדי]; the arc (49) מ"ט [?] is common [מצורף] to two circles — the circle of Aries and Libra [עגול טלה ומאזנים, the equator]; and the arc (23) כ"ג [?] is for the circle of Cancer [עגול סרטן].

[The three arcs are set out and continue with the meridian construction of the next siman.]

סימן רנ"ו (printed §256; logical §257) — to inscribe on this quadrant instrument the arc of the meridian line [קשת קו חצי יומם]

After the greatest altitude of the sun on each of the three [reference days] has become known to you — as the sun arrives at the three points [the two tropics and the equator] mentioned above — now set about inscribing on a quadrant instrument like this the arc of the meridian line. And this is how it is done:

Below, on the arc-of-number, at the [degree-]mark corresponding to the altitude-value, [set the plumb-line] true at the head of Capricorn [ראש מזל גדי] — which is at [degree] 66 [?] — [as in the diagram], and at the point [?] where the plumb-line cuts the arc of Capricorn (which is arc 66, already drawn there), make a mark; let it be point מ"ז [?]. Likewise draw the plumb-line to the degree-value of the sun's altitude at the head of Aries or Libra [ראש טלה או מאזניים], which lie on the equator [קו היושר], the degree [on the arc-of-number] being [39 / ל"ט [?]]; and where this line cuts the arc of Aries–Libra (which is arc 49 [?], the equator itself) make a second mark; let it be point פ' [?]. In the same way draw the plumb-line on the arc-of-number to degree 24 [?], which pertains to [the sun] when it is at the head of Cancer [ראש מזל סרטן]; and on the arc [66/23?] assigned to Cancer make a third mark; let it be point ת' [or ח'] [?]. Then draw one arc from [these marks] — an arc which corresponds to the meridian [חצי היומם] line. And in the same way you shall investigate the arc of the remaining signs, from which the sun's altitude on all the days of the year becomes known to us, as will be explained further below, God willing.

סימן רנ"ז (printed §257; logical §258) — to describe with a compass one circular arc that will pass through any three [given] points, whatever their configuration, provided they do not all lie on one straight line

Although this is not really its place at all, nevertheless — for the benefit of the work [of instrument-making] in this place, which we require — [I set it down here]. [To teach the students the reality of this matter, let us give an example.]

Diagram. A compass construction for passing a circular arc through three given points that are not collinear. Two large intersecting circular arcs form a pointed-oval (vesica) shape rising above a lower circle; short chord-arcs cross near the top and the sides, marking the intersection points from which the center is found.

- ח (given point): one of the three given points
- ב (given point, upper center): second given point
- ג (given point, lower left on the circle): third given point
- ד (upper, arc-intersection): first intersection of the two construction arcs drawn between points ח and ב
- ה (upper, arc-intersection): second intersection of the same pair of arcs
- ו (intersection): first intersection of the construction arcs drawn between points ב and ג [position uncertain [?]]
- ז (intersection): second such intersection
- א (center): the point where line ד–ה meets line ז–ו; the center of the required circle [label position uncertain [?]]

Let the three given points be ג ,ב ,ח, already drawn there. To describe an arc or circle passing through all three: set one leg of the compass at point ח, and with a wide opening set the second leg to swing an arc through [more than half] the interval toward point ב, marking there; keep the compass open at that setting, place one leg at point ב, and with the other leg reversed [swing] toward point ח [א], drawing a second arc. The two arcs cut one another at point ד and at point ה. Do the very same thing between the [other] two points, that is between point ב and point ג, and the places where those two [next] arcs cut are point ו and point ז. Then draw two straight lines — the one through ד–ה and the second through ז–ו — and the place where the two lines cut one another is point א; there is the center of the [required] arc or circle. Set the fixed foot [חוד] of the instrument at the center, which is point א, and widen [the compass] to the distance of [any of] the points ג ,ב ,ח, and describe a circle or arc: its course will pass through all three points.

סימן רנ"ח (printed §258; logical §259) — to know the sun's altitude at the head of each of the 12 signs of the firmament [מזלות רקיע]

When we scrutinize and investigate, through the three arcs [drawn above], the heads of the [remaining] signs, to find how many degrees the sun's altitude is in each and every sign, you must first know that the sun [as a fixed measure] [?] — that is, that the work I am doing is always to one measure and gauge; it neither lags nor hastens in its revolution from one time to another. Nevertheless, [the values of] the sun's altitude at the head of the [several] signs are not [all] near or [all] far, [equally spaced] on the meridian by a single measure and ratio; for sometimes the difference in altitude between one sign and the next is only about 3½° [ג' מעלות ומחצה] [?], and sometimes the difference is found to be about 11½° [י"א מעלות ומחצה] [?] — all according to their nearness to, or distance from, the heads of Capricorn and Cancer [ראשי מזל גדי וסרטן].

[We divided the circle by its points into equal parts, marking on each point the name of a sign, and reckoned it out] [?] — the signs nearest Capricorn [being] more crowded [in altitude] than the rest [?], and [the others spaced] as they are drawn in the [figure of the] circle. This you shall test and see, as depicted in the circle [כצורה שבעגול].

Diagram. A circle crossed by a series of parallel horizontal chords — the declination-bands of the ecliptic. Each chord is labeled with the zodiac sign (or the symmetric pair of signs) whose meridian altitude it represents, the topmost band being Cancer (highest, summer) and the lowest Capricorn (winter); the middle chord is the equator (Aries–Libra). The circle also carries corner/direction labels. Caption above the figure: "כמו שתראה בציור" ("as you see in the figure").

Readable labels:

- טלה (Aries) and מאזנים (Libra): the middle chord — the equator [קו היושר]
- שור (Taurus) / תאומים (Gemini): upper chords
- בתולה (Virgo) / אריה (Leo): chords
- קשת (Sagittarius) / עקרב (Scorpio): lower chords
- דלי (Aquarius) / דגים (Pisces): lower chords
- גדי (Capricorn): the lowest chord [?]
- סרטן (Cancer): the highest chord; label "סר סרטן" at the figure's edge [?]
- corner/direction labels: "ס" ,[?] "נא" ,[?] "ידי"/"ידו" [?] — reading uncertain

By this scrutiny — as you shall test and see, in the figure of the circle — you find the altitudes, and you have to note the recognized measures. [At Prague, above

our horizon, by a pole-altitude of ~50°...] [?] the sun's meridian altitude at the head of each sign is:

Sign (head of)	Meridian altitude at Prague (as printed)	Note
Capricorn (גדי)	16° 30′ [ט"ז מעלות ומחצה]	lowest (winter solstice)
Aquarius (דלי)	20° [עשרים מעלות]	
Pisces (דגים)	28° 30′ [כ"ח מעלות ומחצה] [?]	
Aries (טלה)	printed (100°) ק' [?] — impossible; context requires ~40° (מ')	equinox
Taurus (שור)	printed (21°) כ"א [?] — breaks the sequence; context requires ~51° (נ"א)	
Gemini (תאומים)	60° [ס' מעלות]	
Cancer (סרטן)	64° [ס"ד מעלות]	highest (summer solstice)

[Continuation of §258:]...as you will see with your own eyes: the near and the far [signs] are all equal in their spacing one from another [?], from this [side] to that; [the bands] near Capricorn [do not depart far from the circle-arc, only about... [?]]; and Pisces and Scorpio [ולדגים ועקרב], since they incline more to the oblique [לאלכסון], approach [the equator-arc?] by about 8½° [?]; and [Sagittarius] and Aquarius, inclining still more to the oblique, approach by only a little, about [?] and [Gemini/Leo?] by 11½° [י"א מעלות ומחצה] [?].

As a general rule, know: the more precisely one [computes], the [truer] the sun's meridian altitude at the head of each and every sign [becomes]. [The correspondences are:] Cancer with [the summer band], Taurus with [Virgo?], Aries [with Libra] at the equinoctial band, Scorpio with Pisces, and Sagittarius with Aquarius [each pair sharing one declination-band]. All this you shall test and see, as [depicted] in the figure. And you have to note [?] the recognized measures — [reckoned] by a pole-altitude of [50° [?]] above our horizon here in the city of Prague [פראג], as [holds] for all who share our latitude [ברוחב] — that is, those who dwell [on our parallel] [?].

סימן רנ"ט (printed §259; logical §260) — how the arcs of the signs [קשת המזלות] are drawn on this quadrant instrument

Make, against the right [side] of the instrument, near its edge, two parallel lines [שני קוים מקבילים], set apart [?] a little less than [a certain distance] according to the [width] [?]; and let the lines run from a little [above] Capricorn and descend downward, passing crosswise [דרך שתי וערב, "warp and weft," i.e. transversely] over the arc of the circle of Aries [קשת עגול טלה] until they reach the circle of Cancer [עגול סרטן] — [at the marks] ז"ח [?], כ"ה and ט"ל [?] [that are] in the figure above. Apart from these two lines, mark crosswise the place of the head of each and every sign...

[The construction of the individual zodiac-arcs on the instrument continues; the operative letters/numbers of the marked points are heavily garbled here — the sense is the transverse ruling of the twelve sign-heads across the three principal declination-arcs already drawn.]

You divided [the graduated arc] into equal parts, marking on each point the name of a sign, as the astronomers do; and the place of each is fixed [מקומו כל היום] [?]. Only [the belt of] the signs [inclines] according to the [obliquity]: on the arc [?], and the signs are drawn true [?], [each] to [its] left [and right] [?], the northern [signs and southern signs at their respective marks: ק"ן ש"ד ל"ד [?]]. [When the sun is in any given sign, being in the firmament,] draw the meridian line [קו חצי יומם] [?] — the same lines, ל"ד [?] — and the signs [are set out]...

[The remaining lines of this siman detail, for the sun in each sign, drawing the meridian arc to the marked degree, and are too garbled to render word-for-word; they conclude that from the figure one may read off the sun's altitude at any hour and in any sign, for the days of the year.]

Gate Eleven [שער י"א] — continued

[Continuation of §259 (printed רנ"ט; logical §260).] ...[the reckoning] varies, as will be explained shortly. Know, too, that the signs from the head of Capricorn through the end of Gemini are marked and reckoned [on the quadrant] as ascending from below upward, whereas from the head of Cancer through the end of Sagittarius the rule is reversed, for they are marked and reckoned as descending from above downward. All of this you will find properly laid out, in accordance with its rule, in the form of the quadrant, as above.

§260 [printed סימן ר"ס; logical §261] — Finding the place of the sun among the signs by means of the quadrant, at any time, on any day of the year

Be precise at the very moment of noon, for that is when you must seek to know its place. Sight [the sun] straight against the [line of the] sun[?] until it comes to rest[?] on the two threads of the sight-vane, and observe at which place [of the zodiac scale] the plumb-line cuts across the meridian line — which is line מ׳–פ״ת [?], as above, as in [siman] [?231] [?]רכ״א above. Note the graduation-mark on the plumb-line[?] that rests upon the meridian line, and transfer[?] the bead that is on the plumb-line, as above, as in [siman] [?276] [?]רע״ו. Draw the plumb-line toward the right side[?] to the place of the signs, and at whatever place and degree of the zodiac the bead reaches — that is the place of the sun. For example: suppose the cutting-point[?] falls[?] at the place [numeral: ?] from the meridian line; there transfer the bead and draw the plumb-line to the places of the signs, and you will find the bead falling[?] on the flattened arc at the beginning of Scorpio[?]. [Several tokens of this passage — the specific siman cross-references and one worked-example value — are abraded and are flagged; the procedural sense above is committed.]

§261 [printed סי' רס"א; logical §262] — To find, on any day of the year, how far the sun has moved, and [how far] every star [stands] from the line of rectitude [the equator]

By the general rules already stated for [finding] the altitude, in siman [?]רנ״ח [?258, in exactly the same way you may know [how far] any star's altitude [stands]: a star whose[?] altitude is [numeral: ?], as against the [known] course of the sun, [and its] rising and setting on that day, so that you take the star's altitude and compare it: how much is that [altitude] above or below[?] the number of degrees the sun's altitude reaches — [that is] the star's distance from the sun, and this you learn from the tables[?] of the star's altitude.

[Continuation of §261, top of the left column, p. 149.] …degrees. And when we have found the altitude of one star — for example, 60[?] … 62[?] [doubled?] — we likewise know that star's distance and its declination from the line of rectitude toward the north, 14[?] degrees. [And correspondingly, when we found the altitude of star ח above our horizon at 50 degrees, and the altitude of the equator — already shown to be 40 degrees — we know its distance from the equator toward the south, 14[?] degrees.]

§262 [printed סימן רס"ב; logical §263] — To know the distance of any star from the point of your zenith [נוכח נקודת קדקדך]

Thus: the star whose distance you continually wish to know and to observe — set your heart to it. Sight it at noon [at the meridian line] and observe its altitude; then, from the number of altitude-degrees, subtract from 90[?], and this remainder is [the star's] distance from your zenith, [measured] on the sphere set toward[?] the globe of the earth, as far as[?] the star's…. And to know how many parasangs [פרסאות] this distance is — for every degree [of the sphere corresponds to] some number of parasangs, and it is necessary [to reckon] how many parasangs there are — this distance you must multiply: the aforesaid distance, 15 times 60[?], yields 900 parasangs. [Arithmetic check: 15 × 60 = 900 ✓.]

§263 [printed סימן רס"ג; logical §264] — To know, when the sun enters the head of each sign, how high each sign stands above the horizon at every single hour of that day

The altitude of the sun above the horizon on the day it enters the head of each of the twelve signs of the sky, at noon [half-day], has already been explained above in siman [?228] [?]רכ״ח. And now, so that you may know the altitude of each sign at every hour: I have arranged for you a small table[?] to know the altitude of every sign an hour after noon and an hour [before?]… [and so on for each hour], as follows. [The table appears on the facing page.]

Table. The altitude of each zodiacal sign above the horizon at each seasonal hour of the day. The table is arranged in seven bands, one per sign or symmetrical sign-pair (paired by equal noon-altitude), each band having a *degrees* row [מעלות] and a *minutes* row [דקין] running across the day's hour-columns. The sign-labels stand at the left of each band and carry that sign's **meridian (noon) altitude**; two footer rows of Arabic numerals index the hour-columns (the morning hours ascending and the afternoon hours descending, symmetric about noon). The table reads right-to-left in the source. Per the reading calibration for this run, the sign-labels and their meridian-altitude values are committed; the hour-by-hour interior cells are individually degraded and are given as `[numeral: ?]` (no values are pattern-filled).

Sign(s) — logical order	Meridian (noon) altitude	Hourly interior (degrees row / minutes row, across the day's hour-columns)
Cancer [סרטן]	63° [ס"ג]	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Gemini / Leo [תאומים / אריה]	60° [ס']	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Taurus / Virgo [שור / בתולה]	51° [נ"א, worn — ?]	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Aries / Libra [טלה / מאזנים]	40° [מ']	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Pisces / Scorpio [דגים / עקרב]	28° [כ"ח]	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Aquarius / Sagittarius [דלי / קשת]	20° [כ', worn — ?]	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Capricorn [גדי]	16° [ט"ז, worn — ?]	degrees: [numeral: ?] …; minutes: [numeral: ?] …
Hour-index (footer row 1)	—	printed Arabic: 21[?] · 1 · 2 · 3 · 4 · 5 · 6 · 7 · 8
Hour-index (footer row 2)	—	printed Arabic: 11 · 10 · 9 · 8 · 7 · 6 · 5 · 4

§264 [printed סימן רס"ד; logical §265] — The reckoning of the hours[?] of the day by the sphere-instrument [כלי הכדור], and that their reckoning begins from noon

Root [principle]: Keep this in mind, to reckon and to instruct with this instrument in matters of the hours: [as with?] a matter [numeral: ?], the beginning of each day… [The intervening clauses of the opening are abraded and flagged.] …so that it may be set right[?] toward its [proper] place, and toward the correspondence[?]…

[Continuation, left column, p. 150.] …the setting of the sun, and the midpoint of the hours of night… the rising of the sun in the east[?], and the fourth quarter[?] [is] noon of the day. Enclosed in these [reckonings] you will observe a great disagreement and divergence of opinions, and a great confusion, and much difference between the custom of one country and another. We have already

spoken of them in the gate where we began[?] our reckoning, earlier[?], in Gate 4[?], siman [?105] [?]ק״ה. Therefore know that most of our astronomers[?] have found it fit[?] to begin the reckoning and numbering of the hours from noon of the day, and upon this foundation the Ashkenazim have fixed their clock-hours[?] [שעות] — [reckoned] from the timepiece[?] that indicates the sun for us, [numeral: ?]… a timepiece made from a [gear-]wheel[?]. [Several proper terms in this passage are abraded and flagged; the topic — the dispute over when the day's hours begin, and the German practice of counting from a mechanical clock — is committed.]

[Continuation of §264, top of the right column, p. 151.] …the sphere[?] and its brass[?] and the star, by the weights[?] and by the power of the counterweights[?], and it announces[?] the number of the hours, and it begins to count from noon up to חב״ג[?] and so on, up to 12 hours; and at its completion[?] hour [numeral: ?] and the moment of noon; and likewise at hour 22, the moment of midnight. Upon this foundation the instrument [numeral: ?] is made. And now you will know: when you find [the hour] marked on the instrument, and it is [numeral: ?] — those are the hours [named?] "before-noon," reckoned from midnight; and if [it is] also "after-noon," reckoned from midday. Know, too, that there is some hesitation[?] regarding the hours of the day, from which one begins the reckoning: for example, on Shabbos one begins its reckoning from noon of the day before Shabbos — that is, from noon of the sixth day (Friday) — which is 6 hours before our [ordinary] starting-time; whereas the [others?] hold[?] that their reckoning begins from noon of Shabbos day, which is 18 hours after our starting-time. They have not stated the matter correctly[?].

§265 [printed סימן רס"ה; logical §266] — Graduating the arcs of the hours [קשתי השעות] on the quadrant

Know that as regards constructing the arc of the meridian [half-day], by the method explained above in siman [ר"ס?], in exactly this same way, by the aforesaid procedure, is the constructing of the arcs of all the hours of the day done. How? At the fifth hour after noon we take the sun's altitude — we found it, on the day of the winter solstice [Tekufat Teves], when [the sun] circuits at the head of Capricorn, [to be] 13 degrees above our horizon. We draw the plumb-line down to the number-arc, to degree 13, and at the place where this line cuts across the arc of Capricorn we make a mark. Likewise take the sun's altitude at the hour after noon at the time of the [summer] solstice[?], when it circuits at the head of the upright[?] circle — that is, on the straight [equinoctial] line, when it stands at the head of Aries — and make a mark there, as at siman ב'[?]; and so on [for the

successive hours]. And draw the arc[?] on the three reference-points [נקודות], in every manner just as you observe them for the arcs of the signs[?], on the arc [of the] half-day [meridian], the arc מ״פת [?], as stated above; and so on. Make, and graduate[?], the arcs of all three [reference] arcs — Capricorn's[?] and Cancer's[?] falling at the second hour[?]; so that, after noon, [you graduate] all three arcs [named] "heads," at hour ג'–ד'–ס'[?] up to hour ח'[?].

Behold, it has been explained to you how to graduate the hour-arcs from noon of the day up to night; and I have graduated the hour-arcs of the past hours[?] of the day. Why is it necessary to graduate and place[?] each of them separately[?] at [its] hour? Because after noon, at the arcs [named] "heads," their placement[?] must be set at the hour, just as before noon; because the times[?] the sun rises in their altitudes above the horizon, and likewise in the remaining hours[?], as when their altitude [numeral: ?] is above the horizon — as they [stand] before noon, so they [stand] after noon. And now you know: after [subtracting?] degrees, and their number [numeral: ?]… the marked signs[?] drawn on the plumb-line down to the number-arc [numeral: ?]; and so is the rule at [numeral: ?] and at [numeral: ?], and so [at] each [numeral: ?] and so [at] each [numeral: ?] of the numbered [marks]. All these varied [marks] are shared in one arc[?], as you will see in the form of the quadrant.

§266 [printed סימן רס"ו; logical §267] — That not every hour-arc is always constructed by all the mentioned arc-heads

Know that with the arc of Capricorn on the instrument you cannot use it for graduating[?] the hour-arcs [for more than] 24 hours[?] after its noon, for that is the measure of its half-day [as measured?] by the sun on its arc. Therefore know: when the hours may be placed[?] on the arc of Capricorn — even[?] when the day lengthens and the sun tarries above the horizon after [its] rising, 20 hours and more[?] — then you make the hour-arcs by the two arc-heads, Capricorn and Cancer, that is the arcs of Aries[?] and Cancer, and you proceed with the marks by the aforesaid procedure. And because, when the sun is on the line of rectitude [the equator] at the head of Aries or Libra, its day lasts only six hours after its rising[?], therefore when you finish[?] the hour-arc from the Aries-arc — that is, when the sun tarries above the horizon [numeral: ?], seven hours[?] after noon — you draw the two lines according to the measure of the sun's altitude in them; and the seventh[?] arc, together with the [equinoctial] circle[?], or the arc of Taurus and Virgo, and the arc of 40°, will be near[?] their horizon. All these matters, [being] the ones mentioned, you will see plainly, "eye to eye," above; and it is drawn in the form of the quadrant depicted above.

§267 [printed סימן רס"ז; logical §268] — To know the time of the sun's rising and setting, and the measure of the length of the days and nights throughout the year

When[?] you know the place of the sun among the signs by the method explained to you above in siman [?240] [?]ר״ם, then the reckoning of the aforesaid matters at the time the sun enters the heads of the signs is a very easy thing, requiring neither measurement nor computation, for this is already marked on the hour-arcs at their beginnings[?] on the left[?], up to the beginning [of the arc]. And when the sun's altitude is joined[?] to arc ה[?], from the arc of the signs, at the point[?] [numeral: ?] which is at the end of the arc — a table[?] is filled with the numbers of the hours[?]… [Pisces?] or Scorpio[?] its[?]… shared at the arc [numeral: ?], at the point[?] where the sun[?]… at the seventh hour[?] which is below in the number-arc [numeral: ?] and so on. Behold, [thus] you take the number of the hours: as when the sun stands at the head of Aries[?], its rising is 7[?] hours from midnight and its setting 5[?] hours after noon[?]; so that, by this, the length of the day will be [numeral: ?] hours, and to complete the 24 hours, the length of the night will be [numeral: ?] hours. And so is the rule at the remaining heads of the signs. And when the sun is not [exactly] at a sign's head but has entered [some] known degrees into the sign, then you judge by the proportion of the degrees between the two adjacent sign-heads — the one below and the one above [it] — and further[?], set opposite the arc of the signs[?].

[Note: the source line for the day/night example gives day and night lengths that must sum to 24 hours; the individual figures are worn and are flagged rather than committed.]

§268 [printed סימן רס"ח; logical §269] — To know, on any day, whether it is the time before noon of the day or after noon

Simple: [the body continues at the head of the next page].

[Continuation, right column, p. 152, headed "הוספת" — Supplement.] We reckoned this only when the sun is near the meridian line [line of the half-day]; but to know this matter you must [take] a second sighting[?] of the sun's [altitude] by the method explained to you above, and remember the number of its altitude. Then, after a little while — for instance, after a tenth part of an hour — seek a second time the sun's altitude, and remember that altitude too. If the [second] number is greater than the first, know that [the sun] has risen and has not yet

reached the completion[?] of the meridian, and so it is [still] before noon of the day. And if the reverse be the case — [the second] less than the first — it is known that [it is] after noon. The reason for this matter, to make it plain: it is already known that before noon the sun rises higher and higher, and after its noon it descends lower and lower [numeral: ?]…

§269 [printed סימן רס"ט; logical §270] — To know, at any time, how many hours of the day have passed

On the day you wish [to reckon], be precise to know: seek with the instrument the place [numeral: ?]… of it, [where] the sun [stands]; on that day, for example, take [its altitude?] by the procedure explained to you above, as in siman [?]רל״ח [?238, in the fourth[?] quadrant of sign ט״ה[?]. Therefore, drawing[?] the plumb-line[?] over the signs' marks, set the bead on the aforesaid place of the sun; then extend the thread and set the instrument[?] toward the sun until the second[?] [reading?]… Within[?] the arcs, where the bead of the plumb-line[?] falls[?] below in the number-arc[?] — the number [numeral: ?]… below[?]… [that is the count of the hours that have passed]. [This siman's numerical particulars are worn and are flagged; the procedure — sighting the sun, setting the bead to the sun's place, and reading off where the bead falls among the hour-arcs — is committed.]

§270 [printed סימן ר"ע; logical §271] — To know how high is the axis [the pole] upon which the quadrant is made [i.e., the pole-altitude = latitude]

We have already explained above that every regional instrument must be set right[?] for the place according to the altitude of the axis [pole] there. Now, [suppose] a quadrant [numeral: ?] is likened[?] to your hand and you do not know at what altitude [it is set] — how is the altitude of the axis of the place upon which it was made to be learned by you? Take the point where the meridian line [half-day line] intersects — as above, the arc מ״פת [the meridian] with the arc of the sign Aries [the equinoctial line], which is the marked[?] line — [and] as in the figure above, [with] point[?] ט'[?] as before[?]; then understand the plumb-line, and see how many degrees the plumb-line cuts below on the number-arc.

[Continuation, left column, p. 152.] And you will find 40 degrees. From this you know — from the aspect of the sign Aries, which is the line of rectitude [the equator], as it rises above your horizon southward, 40 degrees — and further, since it is already known that from the horizon to the point of your zenith there are 90 degrees, therefore add to the number "40" to complete ל' [30 — **recte = צ' 90**], and the result [= 50] is [the equator's] distance from the line of rectitude; and

that is the number of degrees of the axis's [pole's] altitude above your horizon. For it is already made plain above [numeral: ?] that by however much [a place] is distant from the line of rectitude, by that much does its axis [pole] rise above its horizon.

[The author's remark — אמר המחבר.] After I had arranged the matters of measuring the altitude of the sun, the moon[?], and the other stars — the arts[?] of measurement — I resolved[?] to put [them] into practice[?] [numeral: ?]. Therefore I saw fit, for [the benefit of] some of my students who have gone through[?] the [science of the] spheres, to teach them also the arts of measurement by means of the sighting-instruments — height and breadth — and, according to the nature of the subjects, the height of tall things[?] and towers[?], the depths[?] of rivers, and [numeral: ?] of mountains[?], slopes[?], valleys[?], and orchards, and their [numeral: ?]. Now this measurement, done with precision, requires us to know the science of number, geometry [surveying], and engineering — of which there is no place [to treat here]. (And I have already composed a book on this, which I entitled *Sefer HaProzdor* [The Antechamber], a book [numeral: ?] written by me.) Nevertheless, to instruct my students, I will teach a little of this measurement in a simple and easy manner, in such a way that they will not need the introductions of the mathematical sciences [as] mentioned.

§271 [printed סימן רע"א; logical §272] — In it is explained the matter of the perpendicular [נצב]

[Heading, second word: printed reads "כוכב" ("star"), which is out of sense here; **recte** most likely "משולש" (a right triangle) or "קו" (a line) — i.e., "the matter of the perpendicular [triangle / line]." Flagged.]

And at the outset: First you must know, in the matter of the perpendicular, the [numeral: ?] and the rule of a right [perpendicular] triangle [משולש נצב]. Therefore know that any column, or line, standing upright in a fully erect posture, without any inclination to the sides, is called an "upright column" [the perpendicular, הניצב]; and when you attach to the column two lines — the horizontal line and the sloping line [hypotenuse] — that triangle is called a "right [perpendicular] triangle," as you will see in the figure, in the form of triangle א־ב־ג. So, for you to understand: the line standing upright plumb, which is line א־ב [as depicted], they call the perpendicular [הניצב]; the line below, which is line ב־ג, is called the base line; and line א־ג is called the sloping line [hypotenuse]. And now know that in every case[?], by the sighting-instrument a right triangle is formed for you. To put it by way of example: suppose you wish to know the height of a

tower א, and the tower is line א־ב [the perpendicular, as depicted]; when you sight from point ג, at a distance [ד־ה?] off, to the top of the tower א, you will find that this observation forms triangle [א־ב־ג — for the line of sight[?] from the eye, from point ג to the top of the tower (point א), which is line א־ג, is the sloping line; the line drawn from the top of the tower down to its root or its foundation, which is line א־ב, is the perpendicular; and the distance from the tower's foundation to the place where you stand[?], which is line ב־ג, is the base line. And we shall know—

[The section breaks off here; §271 continues onward.]

[Continuation of סימן רע"א — printed §271, logical §272]

And know that — as we chose above, at the head of this Gate — the several observations [שמירות] mentioned above are performed in two ways. The first is by means of the instrument [ברית המורה — the demonstrating/sighting instrument? — reading uncertain [?]]; and the second by means of an instrument fitted with the thread of a plumb-line [חוט המשקל]. In the same way, all the measurements before us are likewise performed as described above, in two examinations [בשתי בחינות]. We proceed neither by [?] nor by exact reckoning [צמצום], but only by the examination of the sighting-line [קו המורה]. From this every intelligent student may learn to employ all these measurements, also by means of the second examination.

סימן רע"ב [printed §272; logical §273] — "ביאור המדידה" (an explanation of measurement)

And before we come to the explanation of the measurement, let us preface a short introduction [הקדמה קטנה], in which we shall set out a broad principle in brief terms: that anyone who wishes to measure heights [or lengths] [reading uncertain [?]] and wishes to descend to the foundation [ליסוד]...

[The lemma of similar triangles.] The point of this — one must know and understand it — is that in every triangle, when a further line is added upon it [namely a perpendicular], parallel [כדומה, "similar/parallel"] to [?] the lines mentioned, there are formed within it two triangles: one smaller and one larger than it. Their sides stand in proportion [יתכנו ערך] — the sides of the small triangle in the same ratio as the sides of the large triangle. An illustration of this: we have triangle א־ב־ג [alef-bet-gimel], upon which is erected a standing column [עמוד ניצב], namely line ד־ה [dalet-he], for example. From this there arise two triangles: triangle א־ב־ג, the former and the larger; and triangle ד־ה־ג [dalet-he-

gimel], the smaller. And since line [כ"נ? [?]] and line [ח"נ? [?]] are both common [משותפים] to the two triangles, therefore the ratio of the small triangle [ג־ה? [?]] is as the ratio of the large triangle א־ב־ג — that is [ר"ל]... [remainder of clause not legible: [?]].

Diagram. A right triangle in the right-hand column. Legible vertex labels:

- ג [gimel]: bottom-left corner (with a small foot-mark).
- ב [bet]: bottom-right corner (the right angle).
- [apex, top-right]: label not legible [?] (expected א).

[More than two labels effectively uncertain]

[Continuation of §272, left column, p. 153:]...so that the ratio of the large triangle [הו"ד? [?]] is as the ratio of the small [הקטן, "the small"], such that the ratio of line [ס"מ? [?]] is to line [מ"ט? [?]], and the ratio of line [כ"ז? [?]] to line [ו"ז? [?]], and so on likewise. And whenever a line is added upon the triangle in a slope, the standing line [הניצב, the perpendicular] and the recumbent line [השוכב, the base] being common to the two triangles — therefore the ratio of the small triangle is as the ratio of the large triangle. Likewise, when a perpendicular triangle stands upon a sloping line — as triangle ג־ד־ה [gimel-dalet-he] upon the sloping line ג־ה־א [gimel-he-alef? [?]] — the sloping line alone being common to the two triangles [?], then when the two triangles are completed [broken and reassembled] the small triangle's face is inverted [פניו מהופך], the recumbent side lying uppermost, as in the figure.

Diagram. A right triangle in the upper left-hand column (partly obscured by ink show-through). Legible vertex labels:

- א [alef]: apex (top).
- ג [gimel]: on the base near the right angle.
- ב [bet]: lower-right corner.

Diagram. A second right triangle lower in the left-hand column. Legible vertex labels:

- א [alef]: lower-left corner.
- ג [gimel]: upper-right corner.
- [a further corner label, ד/ה]: not securely legible [?].

סימן רע"ג [printed §273; logical §274] — the construction/adjustment of a sighting-instrument [מחזה]

Although there are many sighting-instruments [מחזים] that the geometers [חכמי המדות, "the masters of measurement"] employ, there is nonetheless one common root [principle] to them all; therefore I shall explain to you [its construction] from the beginning.

I shall explain to you at the outset [כתחלה] the matter of which they [the instruments] are made, so that you will understand also the rest of the instruments [and] why [each is] made as it is; and all the rest of the instruments... their source and root [מקורם] — take for yourself [as an example] the instrument of [?]... [remainder of this passage is degraded and only partly legible: [?]].

[p. 154 — running header p. 154: שער יא — "Gate 11". Right-hand column sits against the binding gutter; right-edge words are clipped.]

upon [the plate], the more finely worked it is, the better; for the larger it is, [the more] precise is its measurement. Always turn the face of the instrument [פני הכלי] according to [?]... in such a way that the instrument be well fitted [יתקן], [the instrument] being made a square [נתרבע הכלי], and you draw line ח [chet] upon all four of its sides, near the edge [שפתים] by about a finger's breadth or less, in such a way that 24 lines [כ"ד קוים [?]] are set out... as established in the figure, the marking [being] as in §272 [כסימן רע"ב] [?]... the two [points] at the angle ג [gimel] of the figure, namely line [כ"נ? [?]] and line [?]... divided and dense in number, it is to be divided into [more] parts, and a large number — such as [?] or [= ת"ן? 450? [?]] parts — [is better]: the more parts, the more precise and complete... so that it not be [subject to error] [?].

Therefore it is more fitting [more valuable] to divide each one of the [main] lines into [?] parts, as shown in the figure.

Furthermore [אחר]: All this you shall do with line ח [chet]; you compose [construct] the diagonal [אלכסון] of [ח"ך? [?]] and the width of the figure like [?]... — [the remainder of the "Furthermore" paragraph describes an attached metal fitting: upon the thickness of the figure you attach [a piece], whether of copper or of tin [מבדיל], and it passes [?]...; and you make in each of them a small perforation for sighting [לחזום], and likewise a small [one];... the motion of the [gauge] of [?]... upon half a degree [חצי מעלה [?]]... and the smaller [it is], according to its smallness, and the more numerous, the better you can reckon [לחשבן] the [?] of the parts, also upon the whole length of the figure... you join this

figure together with [?] in the parallel [בהקבלה] of angle ח [chet], and [?]" — this stretch is largely degraded; specific values and several labels are not securely legible: [numeral: ?] / [?].]

סימן רע"ד [printed "סימן רע'ר" — units letter worn; = § רע"ד, 274; logical §275] — "מדידת רוחב השטח שהוא בארץ המישור" (measuring the width of an expanse that lies on level ground)

[This heading is printed clearly at the head of the inner (gutter-side) right-hand column of p. 154, reading "רע'ר"; the units letter is worn, but the surrounding sequence requires (274§) רע"ד. A prior reading mistook this for §275 and posited a separate gutter-illegible §274 — there is no such extra siman.]

And after I have shown [how] to know the adjustments of the instrument, [and] how it is to be used, we shall now begin to explain [the procedure]:

[When you wish to measure] the width [of an expanse] — [as] the choicest and most excellent [example] of them all — you will [need] to know the distance between point ב [bet] and the point [?] below. You set up the instrument, the [square/level — כלי האנ"ך [?]], upon the ground in such a way [כאופן] that in the figure [one line] faces the sky [פני הרקיע] and line ב־ג [bet-gimel] faces the [ground]; and it faces the surface of the place, or the point, whose [distance] you wish to know...

and you [must] set the [square/level] instrument [האנ"ך] so that it stand upright and straight in its place [ישר ופות במקום...], and place upon it a mark (and again, to this belongs the line of the plumb-level [קו המשקלת], so that the line [?] — this being necessary for the standing of the [square/level]) — in such a way that [the sighting be] complete [גמורה]. And when you have set the whole matter in order according to its rule, you shall [place] the [?] peg of the sighting [יתד המורה], and look [ותראה] through the sighting-holes [חורי הצנורה] downward, until you see through the sighting-holes that are upon the [tube] the point whose distance you wish to know. And [?]... [the passage continues into the left column of p. 154; the concluding lines — "the point ק [kof] on the [square] instrument האנ"ך, through the sighting-holes..." — are legible only in part: [?]].

Diagram. A right triangle (with an internal diagonal). Legible vertex labels:

- א [alef]: apex, upper-right.
- ג [gimel]: on the base, at the right angle.

- ב [bet]: lower-right corner.
- ה [he]: lower-left corner (and a point ה marked on the hypotenuse).

[Body continuing beneath the figure, left column p. 154 — the worked numerical example:] Now you will find in this figure two triangles, one large and one small [הקטן] — the large one [being] the part outside the instrument, [triangle ח־ד־ה? [?]]; and, as we have already shown above [שכבר גלינו [?]], the parts of line ד־ה [dalet-he] of the small triangle stand in the same ratio as the parts of line [כ"פ? [?]], the base, [and] line [כ"מ? [?]] of the large triangle, so that you may reckon how many of the instrument's parts [correspond]. And I say, for example, that line ד־ה [dalet-he] is set at 12 [י"ב] parts, while the width of the instrument is 60 [ס'] parts; so line ד־ה, the standing [perpendicular], is the fifth part [חלק החמישית] of the width of the instrument האנ"ך. Therefore [the corresponding portion] of line א־ב [alef-bet] of the large triangle — whose parts are 60 [ס'] — [is likewise] the fifth part [ה']... and from the recumbent line [it works out]... [so that] the width [of the small triangle / of the expanse] is ten feet [עשרה רגלים]. [The intermediate line-labels and factors here are degraded: [?]; the values 12, 60, "a fifth," and "ten feet" are legibly printed.]

סימן רע"ה [printed §275; logical §276] — "להאריך קו הניצב לדקדוק המדידה" (lengthening the standing [perpendicular] line for precision of measurement)

[This siman's heading and text are printed at the foot of the outer (left) column of p. 154. This is the span into which a prior reading had wrongly carried a verbatim echo of the p. 153 similar-triangles lemma; the actual printed text, read glyph-by-glyph, is the following — it does NOT reprint that lemma.]

We explained above that the larger the sighting-instrument [מחזה] is, the greater the precision of measurement to be found in it. So when the instrument האנ"ך is small in size — such as half an amah by half an amah, or an amah by an amah [?] — the measurement will not carry you out to a distant limit with precision. The remedy for this: you lengthen and enlarge the standing [perpendicular] line [להאריך קו הניצב]. How? You raise the האנ"ך and set it upon a column [עמוד]..., and you take a sighting [בהבטה] along line [?]... [numeral / label: ?]....[reckoning] in the instrument along the length — the mark ח [chet] down to the ground, to the point [?] — and we say, for example, that it stood at 6 [ו'] feet [רגלים]. And now [?]... we say [that] line ד־ה [dalet-he? [?]] of the instrument is the sixth part [חלק הששית] of line [כ"ס? [numeral: ?]]..., [and that] line ח־ד [chet-dalet? [?]] is the tenth part [חלק

עשירי] of line [פ"ז? [numeral: ?]]..., [giving] 6 [ו'] feet... [This siman's remaining worked values are degraded and only partly legible: [numeral: ?] / [?].]

Diagram. A right triangle with an inscribed instrument-square near the right angle and an internal diagonal, at the foot of the outer (left) column (it may be a second impression of the same woodcut as fig-p154-1). Partly-legible labels:

- ד [dalet] / ה [he]: at the top.
- א [alef]: on the hypotenuse.
- ג [gimel], ב [bet]: at the inscribed square.
- ה [he]: lower-left corner.
- [ל? [?]]: a further corner-mark at the lower-right, not securely legible.

[More than two labels uncertain]

[p. 155 — running header p. 155: שער יא — "Gate 11"; folio (77) עז.]

סימן רע"ו [printed §276, set "ר'עו"; logical §277] — the manner of measuring the elevation and height [רום וגובה] of towers or other things [המגדלות או שאר דברים]

When you wish to measure the elevation and height of a tower [מגדול] or other tall things, you set up the instrument upon the ground in the reverse posture from [that of] measuring [horizontal] width. How do you set it up? — In such a way that line א־ד [alef-dalet; printed ח־ד?] faces the ground [פני האדמה], line ב־ג faces the sky, and you aim [ותכוין] the sighting-tube [הצנורה] up and down until you see, through the sighting-holes fixed upon the tube, the point at the top [ראש] of the tower or the height whose measure you seek. For example: in this [case] you seek to know the height of tower ח [chet] which is in the figure — the recumbent line [being] ב־נ [bet-nun? [?]] — and you sight from point א [alef?; printed ח?] to point ג [gimel] in the figure. And, according to what we have chosen [as our principle], there are formed in this figure two triangles, one large and one small: the large one [is] that which extends outside the whole surface [שטח] of triangle א־ב־ג, and the small one [is] that within the instrument [itself], [namely] triangle ד־ה [dalet-he]. Now, according to what we have already explained, the ratio of line א־ד [alef-dalet], the large, to line ד־ה [dalet-he] of the small triangle is as the ratio of the parts of line [כ"א? [?]], the large [line] — namely line ב־ג [bet-gimel] of the large triangle — to the parts of line ד־ה [dalet-he]... — [it is] a computation, for you can see how many parts the length of the figure [has] and [how many] the parts of the instrument [are divided into]. And I

say, for example, that the parts of line [ל"ס? [?]] are 80 parts [פ' חלקים [?]], which are two thirds of [ק"נ? [numeral: ?] = 150], which are... [several values and line-labels in this derivation are not securely legible: [numeral: ?]]. And after this it will be known to you from this that line [?] of the large triangle... [continues; not fully legible: [?]].

סימן רע"ז [printed §277; logical §278] — [the case] when the sight-line [המורה] cuts the upper edge [צד העליון] of the instrument [מהכלי]

When you sight through the sighting-holes of the tube from [?] to point ט [tet] in the figure, the sight-line [המורה, the ray] cuts, in the manner [?], the upper edge of the instrument... [the remainder of the heading-paragraph and its opening lines are only partly legible: [?]].

Diagram. A large right triangle representing a tower with an instrument-square set at its foot; a sight-line runs from the base up to the tower-top. Legible vertex/point labels:

- ט [tet]: apex (top of the tower / top-right).
- א [alef]: on the hypotenuse, upper-right.
- ב [bet]: lower-right corner (foot of the tower / right angle).
- ה [he]: interior point (foot of the small instrument-square).
- ג [gimel]: upper corner of the small square.
- ד [dalet]: corner(s) of the small square.
- ז [zayin]: at the left. Caption beneath the figure (reading uncertain): "[The] place ו [vav], and it is doubled [ונכפל], for example, so that they are 80 [פ']... [ל'] 30 parts, which are 3 [ג']." [More than two labels/values uncertain]

סימן רע"ח [printed §278; logical §279] — how one measures the elevation and height of a tower when one cannot approach the tower [לקרב אל המגדל] and also cannot see its base or foundation [שרשו או יסודו]

When you wish to measure the height of a tower and you have a pool of water [בריכת מים] cutting off [the ground] between you and the tower, so that you cannot approach the feet [רגלי] of the tower, you measure — from a distance — the [span] from the place where you stand [ממקום שבין מצבך] to the feet of the tower, by the method explained above; and it is said [that] you take account of

that distance and complete it in a "sphere"-fashion [כדור? [?]], as is written [in the passage] nearby, §6 [סימן ו'? [?]]. And if there falls out for you in your locality a hill [הר] or [some obstruction] that cuts off [the ground] between you and the tower, so that you cannot see the [base] of the tower but only points on its upper part [נקודות גבהו], its height cannot be known to you [directly]. In such a case you must [work] toward the source [i.e. reduce it to a known] by way of [?]... upon the measure of the great recumbent line [קו השוכב הגדול] — that is, [the span across] the hill that lies between the place of the feet [of your instrument] and the feet of the tower, even though you cannot see that line at all; and for the sake of knowing this you mark the place of the foot of your [instrument] and you sight along the line of the sighting-tube [דרך המורה], looking toward the top-point of the tower's height, and it is said, for example, that [the ray] cuts the bolt [הבריח] on the instrument at [numeral: ?] parts, of which [numeral: ?] are [set] against [a division] on the instrument; and afterward you walk [?]... [the derivation continues, working the proportion of the instrument's graduations against the parts of the recumbent line; the specific values and several line-labels are degraded and only partly legible: [numeral: ?] / [?]. The page ends within this proportion — "...100 parts stand to 20 divisions as the recumbent line of the large [triangle] stands to the first-station line of the triangle..." — the reading of the numerals is not secure: [numeral: ?].]

[Foot of p. 155: printed page-number "77" alongside Hebrew "ר"; folio (77) עז.]

[p. 156 — running header p. 156: שער יא — "Gate 11". This verso's inner (right-hand) column runs into the binding gutter; right-edge words are clipped. §278 continues and concludes in this inner column.]

[Continuation of §278, top of the inner right column, p. 156 — largely obscured by show-through and gutter shadow; only fragments legible:] "...[the parts] according to [what is] still hidden [נעלם] from him [i.e. the inaccessible quantity], and therefore [?]..." [not securely legible: [?]].

Diagram. A tall right triangle for the two-station observation of an unapproachable tower. Its apex [ב? [?]] is at the top; two sight-lines descend from the apex to two stations on the base line, where three small boxes bear woodcut numerals. One box reads legibly **"80"**; the other two boxes' numerals are not securely legible [numeral: ?]. The base points are labeled א [alef] (toward the middle) and ב [bet] (at the right, the tower-foot / right angle). [Apex label and two of the three basal numerals uncertain]

[Text below the figure, inner right column p. 156 — the conclusion of §278, legibly printed here:] Or [alternatively] you take the proportion [תעריך]. You say: "20 [ך'] parts of the graduated divisions [מעלעים] — how many are they [worth]?" — [that is,] in the second position [מצב הב'], how many of the graduated divisions [is] the graduation [worth] in the recumbent line, which in the figure is line א־ב [alef-bet]; and there comes out for you [numeral: ?] divisions, which is the number [i.e. length] of the great recumbent line, which is line א־ב [alef-bet]. And after this it will be known to you [the span] that is between you and the feet of the tower; you complete your measurement by the method [set out] nearby above, §6 [סימן ו'? [?]], and there comes out for you [53 = ן"ג? [numeral: ?]] divisions...

And [as for the case of] a tower [א? [?]] standing upon a hill [ההר], where you seek to know the measure of [the tower's] height and the measure of the hill's height: then you measure, by [means of] two rods [מקלים; printed מלכים], how much the top [ראש] of the tower [rises above] the surface of the ground, by the method explained to you above, §[40 = מ'? [?]]. And afterward you measure in the same way the height of the top of the point [?]. And when the measure of the hill's height is known to you, you subtract [it from] the number of the tower whose measure you have already completed [found] from the surface of the ground, and there remains the height of the structure [בנין] of the tower that stands upon the hill.

סימן רס"ט [printed thus; recte רע"ט? — printed §279; logical §280] — the manner [איכות] of measuring [depth] from a mountain to a valley [מהר לבקע]

After we have come to the measuring of width and of height, there remains for us [to explain] the manner [איכות] of measuring from a mountain [down] to a valley [מהר לבקע]. And by the shorter constellations [ובמזלות קצרות? [?]] its matter will be explained to you, since they are [analogous]: [going] from valley to mountain, and from mountain to valley, in every way [בכל דרך] alike — the triangles [משולשים] that fall out in measuring the mountain [being] like the triangles [?]... the triangles within the instrument [being] like those triangles... [and] all of them fall out in measuring the valley just as [?]... for when one looks [כשהביט] from the mountain [down] to the depth [לעמק]...

[Continuation of §279 into the outer (left) column of p. 156:]...the recumbent line will always be [as described]; and likewise will be the measurement from valley to mountain, or from valley to valley.

Diagram. An instrument-square right-triangle figure (with an inner sub-square and an internal diagonal), in the upper part of the outer left-hand column (partly obscured by show-through). Legible/partly-legible labels: ג [gimel] (upper-right area); further corner-marks א / ל / ז / ד / ה are not all securely legible [?]. A marginal note running along the left edge reads, in part: "...as in the figure: the small triangle — mark it line ו [vav]; and the large one, א־ב־ג; and so it will be with the triangles when you look from a mountain to a valley [בהביטך מהר לעמק], as from point ג [gimel]... to point [?], the small triangle ג־ה [gimel-he? [?]] being similar [דומה] [to it]..." [More than two labels uncertain]

סימן רפ' [printed §280; logical §281] — three kinds of measuring from a mountain to a valley [ג' מיני מדידה מהר לעמק]

And if you stand upon a mountain [הר] and see a great tower standing within the valley [תוך העמק], and you seek to know the measure of the mountain's height — which is line [כ"ב? [?]] — and you also seek to know the recumbent line, which is line כ־ג [kaf-gimel], and you further seek to know the height of the tower standing within the valley, which is line ה־ג [he-gimel]: [proceed] by this [same] measurement. You investigate first the measure of line [כ"ב? [?]], filling it out by means of two rods [מקלים? [?]], by the method explained to you nearby, §[?]. You take hold along the line of the sighting-holes [חורי הביט], sighting from point א [alef?; a point [?]] to point ג [gimel], which is in the figure, and it is said that [the ray] cuts the bolt at, for example, [ט"ס? [numeral: ?]] parts of [תר"ך? [numeral: ?]]; and you walk backward from the tower, for example, [90 = מ"ן? [numeral: ?]] paces [פסיעות], and there you sight a second time, from point ד [dalet] to point ג [gimel], and it is said that there the bolt cuts [ט"מ? [numeral: ?]] parts. Now the [difference] between the two numbers is twenty [עשרים] parts. And according to what we have already chosen above [as our principle], the ratio of this number [i.e. the twenty] to the number of the fewer parts — which are [340 = ש"מ? [numeral: ?]] parts of the second [reading] — is as the ratio of the number of the [?] paces to the number of the paces of line כ־ג [kaf-gimel], which is the recumbent line hidden [הנסתר] from triangle א־ב־ג. Therefore you take the proportion [תיחס] and say: "4 [ד'] parts of the divisions are [340 = ש"מ?]; how many are 40 [מ']?" — [reckoned] as before [וכנ"ל] according to its rule; and there comes out for you the measure of the great recumbent line, [620 = תר"ך? [numeral: ?]] paces; and you have filled out, as [now] known, the recumbent line of triangle א־ב־ג. And you already know, with you, the measure of the recumbent side and the perpendicular of the small triangle which is in the instrument,

namely triangle א־ב־ה [alef-bet-he? [?]] in the figure. From all this [כלל], now, there will be revealed to you the height of the mountain [גובה ההר]. [The specific worked values in this paragraph are degraded; those flagged [numeral: ?] were not verified glyph-by-glyph.]

[Foot of p. 156: printed page-number "77" alongside Hebrew "ר"; folio (77) עז [repeats the p. 155 pairing — see anomaly (d)]. Catchword at foot of the outer column not securely legible:].]

Gate Eleven (שער י"א), continued — surveying

[Conclusion of Section 280 — printed סימן ר"פ; logical §281]

(This computation continues from the previous page — the mountain-and-valley survey: standing on a mountain and sighting a tower in the valley, deriving the mountain's height, the recumbent line, and the tower's height by the two-station method.)

from this you have line א־כ [a–kaf]. Set up the proportion and say: [530 = תפ"ן?] parts in the recumbent line correspond to [340 = ש"מ] in the hypotenuse of the small triangle; so [numeral: ?] paces in the recumbent line of the large triangle — how many are they in the hypotenuse of this large triangle? You obtain the great hypotenuse, [340 = ש"מ?] paces. And to know the depth at which the tower stands in the valley, find the distance from the first station, from point א to point ס [samech], and reckon by the difference of the bolt-readings; the parts come to [numeral: ?]. Now there arise from this two conjoined triangles, the one the general triangle and the other the partial triangle, which returns to it. Therefore set up the proportion and say: [530 = תפ"ן?] parts in the recumbent line are [240 = ר"מ] in the hypotenuse; [numeral: ?] paces in the recumbent line — how many in the hypotenuse? You obtain [226 = רכ"ו?] paces. Take a third of this number and subtract it from the number of paces of the mountain's height, line א־כ, which you already found to be [340 = ש"מ] paces; there remains the measure of the height of the tower: [117 = קי"ז?] paces and 3 [ninths of a] pace.

Section 281 [printed סימן רפ"א; logical §282]

In it is explained: measuring in the case where you cannot walk toward the object — such as measuring from a tower down to a valley.

To stand upon a tower [numeral: ?] and to measure the depth of a valley below, and to measure the depth of a pit — with the base [of the instrument] set upon

the tower's top — set the instrument [with] its openings [aligned] upon [numeral: ?] divisions of the scale.

Diagram. A small surveying figure at the head of the section: a broad low triangle with an inscribed square (the sighting-instrument's shadow-square) set at its apex, and a horizontal base line. Readable point-letters along the base and apex region: ב, ג, [?] ז, ד.

Diagram. A tall crenellated tower drawn at the right, topped by a sighting device (a small ring/eyepiece) and a banner. A long sight-line runs down from the tower to a vertex at the far left, forming a large right triangle whose base is the ground. Readable labels: ג, נ [the pair "נג" on the upper course of the tower], א and ה at the tower's foot, and the far-left vertex ד [or ר — uncertain].

You will say: the observer stationed his instrument upon the tower [numeral: ?]; and [the sight] cut [numeral: ?] parts of the scale, which are the [numeral: ?] of the recumbent line. And the number [of parts] between the two measurements — 240 [= ר"מ] parts of the recumbent line… [computation continues with several interior values illegible: numeral: ?]. It has already been explained to you by the methods given above [how to find] the measure of line ה־ד [he–dalet]: [numeral: ?] degrees. And [thus] the tower standing in the valley is measured, together with the height of the [wall] in the valley. From the first station, from point א to point ס [samech], you reckon by the bolt of the sight through the openings of the instrument… and it comes out [numeral: ?] paces and 3 paces. [numeral: ?]

(The full worked interior of this section is numeral-dense and largely illegible on the scan; the recovered structure is the two-station reduction from the tower-top, but the specific tabulated values are flagged.)

Section 282 [printed סימן רפ"ב; logical §283]

In it are explained the refinements of measurement by means of the sighting-instrument, [showing] how [useful] they are, since they yield great benefit.

Now you, O reader, know and understand well: that all the measurements we have set forth above are all of them by [numeral: ?], for they are [numeral: ?] demonstrated, as is fitting, with uprights and perpendiculars. And now I shall make known to you further measurements by the instrument — for by them you will measure whatever you wish, as the stars [are measured] and as the surveyor [measures]. And they are more general and more inclusive, more precious and

more honored and more refined [in] measuring by them, than every instrument of sighting. And [these are] all the refinements — "from this you know that" [numeral: ?]. And these learnings [teachings] before us will be explained to the students who add [to their knowledge] on this basis, [so that] every matter and its reason will be revealed to them, both this and that. This is the whole matter. And when it happens that a wall of a [tower] is near, or a place is distant, and you cannot approach it — because it lies across a river or the like, and you cannot walk there — you can [still] measure its height, [measuring] its distance from you by the [angle at which the] sight-line [crosses] two [scale-divisions]… [interior values: numeral: ?]. This matter has not been explained above [among] the [prior] learnings; and it is a third kind of measurement, this one newer [and more refined]. It will be explained further: for from the distance between two towers [numeral: ?] you can proceed to know [both] and [derive] a fourth [quantity]. For when the recumbent line is distant and remote, and the place of the recumbent line is remote by [numeral: ?] paces [and more], you cannot [reach it]; yet by measurement it is [found]. [numeral: ?]

(Numeral-dense; interior values flagged.)

Section 283 [printed סימן רפ"ג; logical §284]

In it is explained: to know two positions [שני מצבים] — this one beside that one — and also [the] height and [the] depth [גובה ורום].

And when you have wished to know, in this way, the height of a great tower [numeral: ?], even though you cannot [reach] its foundation at all — [seeing] only its top — from a single [numeral: ?] point: nevertheless you can find and know the measure of the height of the tower, [and] the height of the great tower as well… [interior computation with the isosceles-triangle figure: numeral: ?].

Diagram. A tall crenellated tower (right column of the verso), topped by a sighting ring and banner, with a long sight-line descending to a vertex at the left, forming a large right triangle. Readable labels: ג, נ ["נג" on the upper block], צ, ה ["צה" at the foot], א, ב, and ל [an inner point].

Diagram. A large isosceles triangle (left column) with apex at the top and a horizontal base; two small squares are inscribed along the base (the shadow-squares of the two sightings), and a line drops from the apex to the base. Readable labels: the apex ד [or ר — uncertain]; along the base ג, ה, ז, ב, ד; an inner point ח; and the label יד [yod-dalet] beside the left flank.

You measure line ז־כ [zayin–kaf] by measurement… [interior: numeral: ?]. It has already been explained to you that a measurement of more than [numeral: ?] parts, and you say [numeral: ?] parts — then there arise [numeral: ?]. And you say [numeral: ?] parts in the small [triangle's] hypotenuse are [numeral: ?] in the recumbent line; and [numeral: ?] paces in the [large] recumbent line — how many are they in the [large] hypotenuse? And you obtain the measure of the great recumbent line [numeral: ?]. Now, since the [degrees] amount to [numeral: ?] degrees, and it is [numeral: ?] paces in the small [triangle], and [numeral: ?] paces in the great [triangle] — how many are they in the recumbent line? You obtain [numeral: ?] degrees.

(The section's arithmetic is largely illegible; recovered as a two-station triangulation reduction. Values flagged.)

Section 284 [printed סימן רפ"ד; logical §285]

In it is explained: to know the distance between the [two] points at the tops of two towers, even though you can [reach] only their tops.

To measure the distance between the two tops — the [two] points — of two towers, even though you have no [access] except [to] their tops: measure them by [numeral: ?]. Their points [numeral: ?] — even though there is [nothing] between them but [numeral: ?] points, [set] on the ground; where they are [numeral: ?] and distant from one another, and you need to know the measure of the distance… [The distance is derived] by the reckoning of the measures, [as with] the "cistern-fraction" [21 = א"כ?], and the place is [numeral: ?] upon you… [interior: numeral: ?].

(Worked example — the two exemplar towers:)

Diagram. A large triangle at the head of the right column, illustrating the two exemplar towers. The right (vertical) side is labeled with the large numeral **7000** and the sloping side (hypotenuse) with **5000**; the apex is marked ח [chet], the left vertex ד [or ר], and the right-hand points ב ,ה ,א. Captions above the figure name the towers: מגדול השן ["the Tower of Ivory," Shir HaShirim 7:5] and מגדל הלבנון ["the Tower of Lebanon," Shir HaShirim 7:5], used here as the two standing towers whose separations are 7000 and 5000 units.

You wish to know the distance between the two points at the tops of the two towers, as from ב to ג; and to that end [take] the Tower of Ivory and the Tower of Lebanon. So must you first know the distance of each one from the place where you stand, by the fourth method explained to you above in the [section]

immediately preceding… [reckoning by the sighting]. We found that the distance of the Tower of Ivory is **seven thousand** [7000 = אלפים ז'] and complete [numeral: ?] degrees, and the distance of the Tower of Lebanon is **five thousand** [5000 = אלפים ה'] degrees. Take the instrument of sighting and set the sight-bolt to its notch, and observe through the sighting-openings toward the point of the top of the Tower of Ivory, and leave the instrument in its place — do not move it at all — only the sight-bar you turn toward the width of the instrument until you sight, through the sighting-openings, the point of the top of the Tower of Lebanon. Then there arise for you two triangles: the large one is the whole triangle א־ב־ג [alef–bet–gimel], and the small one, [inscribed] in the instrument, is triangle א־ד־ס [alef–dalet–samech]; and this small triangle [is similar to] triangle א־ב־ג. [Since] it is triangle ל־כ [numeral: ?], you must divide it into two right triangles, as is the rule…

You draw a line from point ג [numeral: ?] up to line א־ב [numeral: ?], reaching as far as point ז [numeral: ?]; and there arise two large similar triangles, [namely] triangle א־ד־ז [?] and triangle ז־ב־ג [?], according to what has already been set out in [terms of] their proportions above… [interior computation: numeral: ?]. Line א־ד [alef–dalet] of the small triangle [is to] line ז־ב… by the proportion [numeral: ?]. And behold, line ה־ד [is] [numeral: ?] parts. Therefore reckon and say: if [numeral: ?] are [530 = תפ"ן?] in the small triangle, [and] three thousand [ג' אלפים 3000 =] in the hypotenuse — how many are they in the recumbent line of the large triangle? You obtain **four thousand** [4000 = אלפים ד'] degrees; and this you subtract from six thousand [6000 = אלפים ו']. And the complete degrees, which are the number of degrees of line ז־כ [numeral: ?]. And to know [the number of degrees of] line ב־ג [bet–gimel], it is made known to us by the reckoning of the theorem [i.e. the Pythagorean rule]: you square the numbers of line ו־כ [numeral: ?] and line ז־ג [numeral: ?], each of the two of triangle ד־ב־ג [numeral: ?] by itself, and add together what arises from this, and from it extract the square root; and you obtain **four thousand nine hundred [and] some** [ד' אלפים ות"ס? — numeral: ?] degrees. And this is the number of degrees from the point of the top of the Tower of Ivory to the point of the top of the Tower of Lebanon, and so forth.

Section 285 [printed סימן רפ"ה; logical §286]

In it is explained: to know [the measure of] the height of a tower or a tree by its shadow, in a very easy way.

If a tower, or a tree, or [some other] single [thing] stands on level ground, then you can know its height by [means of] its shadow. Chazal already anticipated us

in this, in Tractate Eruvin [Eruvin, on gnomon-shadow reckoning]: how you measure the ratio of the whole of your body when you stand at [some] place; and [reckon] the length of your shadow [in proportion] to the length of your stature; or the ratio of the shadow of a wall, or of a staff, in proportion to its height — and from this you know the measure and extent of the height and elevation of the tower, according to the ratio of its shadow.

An illustration of this: thus, the measure of your stature, say, is **7 feet** [ז' רגלים], and the measure of your shadow is **9 feet** [ט' רגלים], and you have measured the shadow at the tower, say, at **100 feet** [מאה רגלים]. Set up the proportion and say: the nine feet [of my shadow] correspond to the seven feet [of my stature] — likewise, the hundred feet [of the tower's shadow], in the same manner, how many [feet of height] are they? Complete it according to the rule, and it comes out **77 [feet] and seven-ninths** [77 7/9 = ע"ז רגלים ושבע תשיעיות].

Section 286 [printed סימן רפ"ו; logical §287]

In it is explained: knowing the height of a tower by its shadow, apart from [using] the measure of your own body.

If, with the sighting-instrument mentioned above, you observe through the sight-openings where the ray of the sun [falls], and [read] the ratio of the division which the sight-line cuts on the upper part of the instrument in proportion to the side of the instrument — that is the "straight shadow" [צל היושר, umbra recta], [which gives] the height of the tower. And [if you read] the divisions which the sight-line cuts on the lower part of the instrument in proportion to [the side of] the instrument — that is the "reversed shadow" [צל ההפוך, umbra versa].

Diagram. A right-triangle shadow-square (drawn at the foot of the page, spanning across the columns), representing the two shadow-scales of the instrument. The hypotenuse/upper scale is labeled **צל היושר** ["the straight shadow" — umbra recta] and the inner/lower scale **צל ההפוך** ["the reversed shadow" — umbra versa]. A catchword appears below.

An illustration of this: you have found the shadow of the tower to be **100 feet** [numeral: ?]; and when you sight through the sight-openings [along] the ray of the sun, the sight-bar cuts, against the lower [scale] of the instrument, **80 [= פ']** divisions, which are **240 [= ר"מ]** by the measure of the side of the instrument. Therefore the **80** divisions are [numeral: ?] of the instrument, and that is the "reversed shadow." By this reckoning, [the height] was: line ה־ד [numeral: ?], the recumbent line — that the instrument is complete from the recumbent line, [and

so] we know from this that the tower is complete [i.e. its full height is determined]…

(Interior instrument-scale values are partly illegible and flagged; the recovered content is the umbra-recta / umbra-versa shadow method.)

Section 287 [printed סימן רפ"ז; logical §288]

In it are explained: measurements easy and simple for [finding] height, for builders [and every man], even for those who have no knowledge of the science of measures at all.

Some plain folk, like our fellows, who are not skilled and [barely] understand — who scarcely know their right hand from their left — when they wish to know whether a certain tree [numeral: ?] from within the forest is sufficient for them for a certain beam, or for some [other] purpose, and they are only able to walk to the place near the root of the tree: they go and measure by this method. Take a square block of wood [עץ מרובע], and at one of its corners tie the plumb-weight [המשקל]; and observe from the [face] of the block along a line toward a point [numeral: ?]… and do not [need any instrument] until [the moment] you [hope] the plumb-weight falls upon the [corner] ז [zayin]… the lower [side] fixed diagonally opposite the corner ז… the line [numeral: ?] within the square block along the diagonal… [numeral: ?] equal divisions — thereby you know the height of the tree and the distance between you and it, [without] any [instrument].

Another method, this one too very easy: Take a [numeral: ?] block, cut it from corner to corner along the diagonal into two [triangles], and there arise two right-angled triangles… [set one so that] the diagonal [is level and] the recumbent line and the plumb-line stand upright; then you sight this square [numeral: ?]… [and derive] whether the height is [numeral: ?]. The plumb-weight stands [at] its full height, and [you] surround [reckon] it, and [the reckoning] returns [numeral: ?] the [sight-]line [numeral: ?] to the diagonal…

With the help of God, the God of the spirits of all flesh [בעזר אל אלהי הרוחות לכל בשר].

(Interior values illegible; recovered content is the carpenter's-square / plumb-diagonal method. Flagged.)

Section 288 [printed סימן רפ"ח; logical §289]

To find the height of a tower or a tree or the like, by means of a spear or a staff — without any instrument.

When you have no sighting-instrument whatever, and you wish to know the height of a tower, or a tree, or some other structure: take a spear, or a single rod, whose length is about **twenty feet** [כ' — ע"ד עשרים רגלים], or less or more, according to your [convenience]; and fix it upright upon the surface of the [ground] whose height you wish to know, [standing it] according to your [line of sight]. [Then lie down] and cast yourself backward little by little, until you see, along the top edge [ק — the top] of the spear, up to the point of the top of the tower or the tree, [numeral: ?] its height.

[Set up the proportion:] the distance that lies between you and the spear is **twenty feet** [עשרים רגלים], and the distance between you and the tower — which is [numeral: ?] — will be the ratio of the first recumbent line; that is to say, [from] your feet up to the spear, in proportion to the recumbent line of the height of the spear, which is twenty feet; in the same ratio as the number [of feet] between your feet and the tower, which are **60 [= ס']** feet, in proportion to the height of the tower. Complete it according to the rule, and you obtain the measure of the height of the tower: [numeral: ?] feet, and [numeral: ?] you add the measure of the height [from] the ground up to your eye [i.e. your eye-level], as above.

We have completed the eleven Gates. [השלמנו שערים אחד עשר]

The Twelfth Gate (השער השנים עשר)

This is the supplementary Gate, in which are explained scattered topics: concerning the comet-stars [כוכבי השבט] — whence they come and are generated, and their motion; likewise, [it treats] of the signs and eclipses of the luminaries, and of the visions of the seers [astrologers], whether they are true or [vanity]; and of the doctrines and the tales of the constellations of the zodiac, and their [influence] and [import]; and whether we, the congregation of Israel, are placed under the dominion of the stars, and [whether] the forms of the heavens are [drawn] for it; and the matter of the **twenty-eight** [28 = כ"ח] mansions [מחנות] of the moon; and other matters besides these.

Section 289 [printed סימן רפ"ט; logical §290]

On the matter of the tailed stars [comets], called in the language of Chazal "kochvei shavit" [כוכבי שביט — comet-stars].

We have already explained above, in a general way, in our brief words, [that the world is composed] of the four elements, which [lie] one above the other; and we have shown, in general and in particular, [the nature] of the [numeral: ?]

wandering stars and the [fixed] stars of the constellations, and their [natures]. There remains for us to choose [i.e. to treat] of [numeral: ?] stars — these are the tailed stars, called in the language of Chazal "kochvei shavit" [comet-stars]. And they are of [various] kinds and hues; many of them are large and some of them are small; [some are] round without any [tail], and so forth; or [some appear] as though [each] of them were seen as a ball whose [rays] are [gathered] great, or as [threads]; [some] like the generation, that is to say, like loaves of [flame]... some of them in the likeness of [numeral: ?] seen in them; and [smoke] happens [to rise from them], some of them in the likeness of tails and long [diagonal streaks], and [tails] like [those] of horses, this one after [and unlike] that; and [some] going along and shining, like the likeness of a long rope; some of them red, and [some] of another color; and some of them [another] color, and this one [yet] another color, and this one darker; some of them inclining to green. They are also called at times, in the sky, in the likeness of [numeral: ?], [in] the shape of animals or birds, or [some] other likeness. From here on it will be explained to you, in brief and in a general way, according to the view of some of the investigators... and this is the place [to treat of] their generation — whether the comet-stars are [in] the [sphere]...

(Continuation of §289 [printed רפ"ט], from the previous page, catchword גלגל.)

the sphere of the constellations; or else from the power of the spheres of the six [?] wandering planets; or within the lower elements. And [the comet] revolves either eastward or westward, or [in some other way]... for [its motion] is [greater / less] than [the ordinary] motion [?]. All of this has been investigated [?] and set down at length, and abridged [?].

סימן ר"ץ — Siman 290 (printed 290 = ר"ץ; logically §291)

Where the comet-star is located in the firmament.

Most people imagine that the comet-stars [kochvei shavit] are like the other fixed stars — except that, according to the view of Ptolemy [בטלמי'], they rise higher and higher and become hidden from the eyes of men; and then, at another time, after a while, they return and descend, and become visible again. Understand, however, that in the science [of astronomy] the matter is not so. Rather, the place where they turn is within an [ordinary] sphere [galgal] or [in] the air, and this has been established for the astronomers by a complete demonstration: [namely,] how far [these bodies] are raised above the sphere of the earth, and its [measure] fills [thousands...] more [?]; [the comet] falls [descends] and comes close to the earth, spanning several thousand parsangs [חלפים / אלפים פרסה].

סימן רצ"א — Siman 291 (printed 291 = רצ"א; logically §292)

The cause: from what and whence the comet-star comes into being and is generated; how it appears suddenly and, little by little, wanes and fades; and also its cause, and the nature of thunder and lightning — which will be explained to you incidentally.

As for the cause of the [existence / generation] of the comet-stars: the investigators wrote that it is something remote from nature, and also like the thunder and the lightning, which are natural [phenomena of the upper region] — as the sage [ראב"ע = Abraham Ibn Ezra; printed רחב"ע [?]] attested regarding this, on the verse "there were voices and lightnings [and a very loud sound of the shofar]" [Shemos 19:16], where he wrote that the "loud sound like a shofar" was the thunderclap [?] — [evidence] that they are not [supernatural], that is, that they are natural, like the thunder and the lightning. And just as the cause of the rainbow, which is visible to the eye and which the ancients described, is a natural thing, so too there are [comets] among those mentioned [that are] natural. And [this] informs [us of] the nature of the thunder and the lightning, from which we descend to [understanding] the nature of the comet-stars… [The remainder of this passage is closely argued and partly abraded; the author reasons that one must judge each matter by what has already become known, examining every naturally occurring phenomenon: it arises and is generated in a downward direction [?] on account of [heat] rising from the earth and returning [?]; and likewise every such matter — from whatever cause and in whatever likeness — arises in the world by its nature and returns to the place where its element is [most] fixed.] [several clauses here uncertain [?]]

And now you shall know, from the investigators, that its cause [is bound up with] the [exhalations] rising from the earth — and similarly [certain] signs — and [the vapors] that rise upward, [where there are] several kinds of [new] phenomena. And matters of this kind [arise and pass] according to whether they are cold and [dry], or hot and moist. And as they rise upward and grow, they resemble [tails / streaks?] by means of [the sun / their heat] and… so that, as it were, they are consumed [?] — either from cold and dryness, or from an excess of heat [?] — and rise up near the sphere of fire [where, being small at that distance, they are no longer seen]. And there is renewal of vapors, and they rise from the earth and [pour down] rain, moisture, and water, so that it seems that the clouds fill with green [vapor] upon the earth, and [these clouds turn to different colors]. [passage partly conjectural — several readings [?]]

סימן רצ"ב — Siman 292 (printed 292 = רצ"ב; logically §293)

The courses, or the revolutions, of the comet-stars [kochvei ha-zenavot, "the tail-stars"].

The comet-stars [tail-stars] have no known and ordered path; their motion or revolution is found only by [observation]. First, in the view of those who [rely on tradition], they stand in the air, or in a sphere [galgal] [of their own], in a [certain] place, and have no revolving motion at all — not even the diurnal motion [tenu'ah yomit] [that carries the heavens]. [This view holds that] their cause [and their coming into being lie] in [the lower region]; [the passage here is much abraded — several clauses [?]].

[There is a further view] that [a comet] has a wandering, confused, and highly irregular path: it revolves [in various ways], and sometimes [holds still / moves] with [difficulty of observation], and sometimes stands still — a matter whose observation is very difficult, and is far removed from [regular] nature. [It is on this account that] the astronomers alarm and frighten the people with such a star.

[The author here reports that observation distinguishes] the comet-stars into **four kinds** of revolution for each one: (1) the diurnal [motion], like [that of] the other stars; (2) a proper motion of its own, like that of the other wandering stars, sometimes moving like [one of them]; (3) that it moves at times sidewise — southward and northward, and [from north] to south; (4) that, as its power drains from it, it descends lower and lower [in the first case], until it is consumed and vanishes — or, on account of [an excess of] its heat, it rises higher, up near the sphere of fire [גלגל האש?], where, because of its smallness [at that distance, it is no longer visible]. [several readings [?]]

סימן רצ"ג — Siman 293 (printed 293 = רצ"ג; logically §294)

How long the comet-star lasts and remains visible.

Most comet-stars neither vanish nor perish [within a few] days of their appearing, nor do they last more than about eighty [days? — the numeral is partly effaced [?]], [reckoning] from the mean [of their period]. And the star that was seen over the region of Jerusalem [?] [lasted] such-and-such [?] — as did [other] comet-stars. Others besides them — such as the star [seen] in the year 1532 [?] [Hebrew: אלף תקל"ב [?], by their (Christian) reckoning] — stood [visible] for more than a full year; those stars [remained] there [a long time]. [This is contrary] to the [ordinary] nature of the other comet-stars. And there is no doubt but that [in] the [regions of certain lands], the Blessed [God?] [caused it to endure]

longer than the other comets… [The astronomers wrote that one should not] observe [the fixed stars in the way one observes a comet — for a comet is] long, or has a great [tail]; and it stands and lasts a long time — whereas… [The astronomers said] that one should not heed this sign, as [above]; and they saw a certain star that had a great, long tail, remote [?], [visible] in the firmament for only twenty [?] [ב'?] months. [several numerals uncertain [?]]

סימן רצ"ד — Siman 294 (printed 294 = רצ"ד; logically §295)

In which region of the firmament the comet-stars [tail-stars] usually stand.

Most comet-stars, [called] "[crinite] stars" [כוכבי כנפים?], are situated [each according to its power] at the points of the sphere of the zodiac — [in the signs] Taurus and Gemini [?], and at the point of the head of Cancer [?]. And [the comets called] "tail-stars," [which appear] outside the [aforementioned bounds] — these are large and [round?], and their [rays gather]; sometimes [one appears] entirely opposite [another], with nothing between them — [several clauses abraded [?]].

סימן רצ"ה — Siman 295 (printed 295 = רצ"ה; logically §296)

That in most cases comet-stars [kochvei shavit] appear [before a great event] — or [other] signs of the heavens.

[Suppose it were true] that all comet-stars, or the other signs of the heavens, indicate the death of kings, or the destruction of a [region] or a country; and suppose it were further true that no evil comes into the world unless [a] sign of the heavens precedes it. It would then follow that there is no year in which a comet-star — or [some other] sign of the heavens — has not appeared; only that it is not seen in every place, since there is no year in which some great ruler does not die, or in which there is not [some] destruction and great slaughter in one of the countries.

סימן רצ"ו — Siman 296 (printed 296 = רצ"ו; logically §297)

Whether it is possible for the astronomers to know and foretell a comet-star before it comes.

Know that the matter [is] as follows: when [the atmosphere] draws on, and a long time passes in which it is dense and [thick] and full of moisture, [it does] not fail to bring us great thunder or lightning, or comet-stars, or [other] signs of the heavens — on account of which [there arises] a great [conjunction / vapor] [?] … [The astronomers disagree, in the science of astronomy and observation, about

all matters of their generation.] [The astronomer Peter [פיט"ר [?] — the name is garbled]] once wrote that in the year 1531 [Hebrew: אלף תקל"א — confirmed under magnification] he saw, in a vision, [a portent of] his year, and said that the coming danger [was] such [?]; and that in the year 1532 [Hebrew: תקל"ב — confirmed under magnification] he saw, in his visions, [something like] wandering stars [planets], and the sphere of the zodiac was full [of them], and [naphtha / fire] and [sulphur — leg,garbled [?]], [foretelling] that in a year such as that there would be [wind] and rain and [thunder and lightning] — very marked, without [ordinary] rain — from which there would come to be [storms?] in that year, [in] the season of winter; and all [saw] one great and awesome star with a great long tail, and so it was.

And the astronomers further measured [this comet]: the length of the diagonal line [קו האלכסון] was about one parsang and a quarter of a parsang; and the [other] line they reckoned at 183 [Hebrew: קפ"ג — confirmed under magnification] parsangs.

סימן רצ"ז — Siman 297 (printed 297 = רצ"ז; logically §298)

Whether the [portents] of the luminaries [i.e., eclipses] announce or foretell evil decrees.

The author says: Having explained the cause of the eclipse of the two luminaries and the matters of the comet-stars, I saw fit to speak here, by way of a hint, [about] the two [kinds of] eclipse — [of] sun and moon — and the other signs of the heavens: whether what is destined to be is thereby made known to us. And I estimate — and first assert — that it is true, and cannot be denied in any way, that the eclipse of the luminaries announces and foretells evil decrees, as Chazal already testified concerning this, in that they said: "When it [the sun] is eclipsed, it is a bad sign for [the whole world]" [cf. Sukkah 29a].

And as for the eclipse of the luminaries — the difference [lies] in the motion of the earth between the sun and the moon, as stated, and it is found, according to [reckoning], that every eclipse is [natural]. For from the six days of Creation the Blessed One set them in their order, and He does not renew [them]; the luminaries never deviate, nor hasten, nor delay, nor come early, nor come late in their motions — ever — but [move] as [expected] according to the greater part of their reckoning [?]. And this is what Chazal said: "Whoever knows how to reckon the cycles and the constellations [tekufos u-mazalos] and does not do so…" [Shabbos 75a] — [that is, a man of] understanding, knowledge, and intellect [is able] to reckon and to know every time an eclipse will occur, [to the] day, the

hour, and the moment of a partial [eclipse], to the end of all generations; [it all depends] upon them.

(continues, top of the next page) To them [these fixed motions] nothing is added, and from them nothing is subtracted, [being] the same from everlasting to everlasting. And since this is so, it is very far [from reason] to accept that an eclipse which must, of necessity, come to pass — precisely by its nature — should [be taken as a decree]; [for it was] ordained, from the days of Creation, that [the heavens should be] fixed [?] and set as an array of stars, to [foretell] evil and punishment to the world for its wickedness. For there is no punishment without sin, and [when men are] all called "sons of Adam" [and] are compelled in their deeds — this is a matter of absolute inquiry. Nevertheless, we cannot deny, on account of the shortness of our comprehension, that which the [very] eye testifies to, and which [reason itself] sees. And [as] one who [comes] to settle this perplexity, [in] the tight [?] straits [of the question], let me say: since it is already known to us that "the inclination of man's heart is evil from his youth" [Bereishis 8:21], [and] since the deeds of men in the world at every time and hour [are such], they are liable to destruction — were it not for the mercies of the Blessed Lord. Therefore He, may He be blessed, established, from the days of Creation, [these means] to show to the sons of men His signs and a chastening rod, once He had set revolving spheres in motion; and these [spheres] do not, of themselves, [suffice] for the dominion of the stars, in their [natural] course, to bring the matter of great famine, or [any] other punishment, God forbid.

סימן רצ"ח — Siman 298 (printed 298 = רצ"ח; logically §299)

Whether the astronomers' [predictions] come to pass without fail, or whether there is found in them empty pretension and delusion.

Incidentally [aggav gerera], I saw fit to speak here, in a brief note, of the astronomers' [predictions] — [the visions] they see concerning the eclipse of the luminaries, the comet-stars, the [other] signs of the heavens besides these, and, [generally, all] the rest of the [predictions], as [they prophesy] by the customs, the courses, the "judgments," and the [terms] of the stars. And I say, in my humble opinion, that the matter is not true, and will in no way hold up; for the astronomers have many times foretold [a nation's] future — for instance, the death of a king, or the destruction of a country — since this is [a work of] conjecture.

And that which [Abraham Ibn Ezra — printed רחב"ע / סאכס [?]] wrote in [Parshas] Ki Sisa [Shemos 30ff. [?]] — that the matter is founded [thus]: when [the

planet Saturn — mazal Shabtai [?]] bears witness in an evil array, it foretells evil for [Israel]; and if they [Israel] are not subdued, [the constellation of] Shabtai [Saturn] is [bound] to them — as the aforesaid sage [Ibn Ezra] wrote there, in [Parshas] Yisro, on the verse "Remember Shabbos day" [Shemos 20:8]; and the author of *Meqor Chayim* [בעל מקור חיים [?]] also wrote thus in his name, in [Parshas] Vayikra, on the verse "you shall offer the offering of the first-fruits" [Vayikra 2:12]. And we have already explained elsewhere that the matter is founded [thus]: when [the planet Mars — mazal Ma'adim / מרי [?]] is in a good array, it foretells good for this or that country — [namely] the country of [those under it] — and, conversely, [the reverse].

It is already known that the astronomers, when the time and moment of the birth of a certain man is known to them, calculate and set their aim at many things — what will befall him from the moment he leaves his mother's womb until he returns to his dust; and they call it, [in a foreign tongue,] "*nachti visent*" [transliteration uncertain — perhaps "nativity" [?]]. And we have already found that the astronomers have set their aim, and foretold, great and [wondrous] events before their coming. We have found the like of this, too, in the words of Chazal, at the end of the chapter [*Ba-Tra*] of Sukkah [Sukkah 29a]. Nevertheless, know that, for the most part, they do not aim aright in [predicting] [the eclipse / the event]; and it was on this that Chazal aimed, in what they expounded on "from those things that shall come upon you" [Yeshayahu 47:13].

And know, further, that among the many seers — all of whom are eminent in the science of divination — nevertheless, not at every time is each one aimed aright according to [the reckoning of] his fellow; nor is this all: sometimes the one announces and foretells the very opposite of his fellow, for each judges according to the sight of his own eye and mind. And this could not be so were there not, [in it,] dispute, argument, casuistry, and the contradiction of one against the other — as [there is] in the rest of the matters of astronomy — because [the visions used] to foretell the future are not [certain] like the [demonstrated] sciences, such as astronomy itself, which is founded upon the demonstrations of philosophy and rests upon proof.

Its subject-matter, rather, is [empirical] experience [nissayon]; and for this reason it is not called "the science of divination," but "the craft of experience" — as the sage R. Avraham bar Ḥiyya wrote in the introduction to *Sefer Tzuras ha-Aretz*, in these words: "And this part is not reckoned among the science of true knowledge…" — [rather] it is called "the craft of experience," for it is a derivative of the science of divination — end of quote.

Know also that the greatest and most eminent of all the seers does not [pray / assert] and say, "Assuredly the matter of so-and-so points to such-and-such," or say, "Assuredly, and without fail, such-and-such will come to pass"; for the more learned the seer, the more the matter is, for him, in doubt — since all admit that many [things nullify] the [predictions of] the decree of the stars. Sometimes [the decree] is nullified through the merit of [repentance] or a [mitzvah], as they said at the end of the [last] chapter of Shabbos [Shabbos 156a]; and as they said in the first chapter of Rosh Hashanah [Rosh Hashanah 16b]: "Four things tear up a person's decree." Sometimes it is nullified for another reason, [known] to the Revealed One [God] alone. It is also known that, for many reasons, the [predictions] of the array of the stars are nullified — as all the commentators wrote — [as in the case of] Shmuel [when a person] was cut off [?] [or] fell in war and was captured. And [as] it appears that sometimes men have entered a certain ship and gone down into the sea, and all of them drowned in that ship; or [as] in one year a thousand men were slain in war — there is no doubt that all this did not come [to pass] according to the array of the stars, but rather all of it by [nature], as [the author of] *Sefer ha-Ikkarim* [wrote] in Maamar 4 [?]; and he wrote there further, in the name of the sage [Ibn Ezra — printed רחב"ע [?]], who wrote in *Sefer ha-Moladot* — [that] all these things nullify the [predictions] in [their] particulars. And by way of general principle, know that, in truth, the matter [is] that all the creatures below are given under the dominion of the stars — as Chazal said: "There is no blade of grass below that does not have a constellation [mazal] above that strikes it and says, 'Grow!'" [cf. Bereishis Rabbah 10:6]. So too, the stars and constellations — [and their radiations] — all receive [their] power [and nature] from the One who spoke [and the world came to be], who alone has the might and the dominion to make great and to strengthen, and to demolish and to shatter the decrees of the array of the stars.

And you, O reader, know full well that "the law has been [entangled]," and how many pens have been broken over the divination of the gentiles' astronomers, who go [astray] — who gathered together to foretell the future for the year 1188 [?] [Hebrew: אלף קפ"ח [?], by their (Christian) reckoning] — [that is,] the year 341 [Hebrew: שמ"א = 341(5) AM; 5341 − 3760 = 1581 CE] by our reckoning — [a matter] not [hidden] from the wise of their generations; and this, indeed, [was foretold] many hundreds of years before. And it followed, by the [predictions] of the stars, that in the year mentioned the end of all flesh would come, and the greater part of the world, in its entirety, would return to chaos and void.

[Yet the truth is otherwise:] the Exalted and Lofty One [holds] in His hand alone the soul of every living thing; He, the Almighty [Shaddai], orders the arrays of all

the stars as He wills, [being] the master of the world — and He [nullifies / denies] [their word], so that they did not [perceive] that in the year mentioned there would be no [destruction] or plague in the world. On the contrary, the reverse: we saw that in several [years — reading uncertain [?]], even [reckoning by the standards of] the destroyers, we did not find a single quiet year, so [it was] fitting [that there should be some] on account of much famine, [each] by its nature, as [above]; yet in most of those years — in which the seers, [reading] the signs of the heavens, were alarming and frightening the people with their visions, announcing [war?] and famine and the destruction [of a country] and the [loss of] a country's wealth — at that very time the kindness of the Lord filled the earth, in such a manner that neither destroyer [satan] nor evil mischance was felt [?]. [And there is nothing] to Chazal's [words? — reading uncertain] like the daily [predictions] of every single day, as is set out [in] their tables, which fix: on such-and-such a day there will be rain; on such-and-such a day, snow; on such-and-such a day, frost; and on such-and-such a day, a storm-wind — [predictions] which, for the most part, according to their [own words], do not come true. [This concluding passage is partly abraded; several clauses [?]]

(continues, top of the next page) This is what Scripture called them: "false diviners" [bodim] — as it is said, "who frustrates the signs of the [false diviners / bodim]" [Yeshayahu 44:25]. [And Rashi] explained there that [these] are those who [foretell / read the future] by means of the stars, by [heavenly] signs; and see there, [in that passage,] that Scripture [likewise] calls [several such practitioners] "bodim." [In this way] you shall know that the visions of the astronomers, in foretelling the future — even should they, at times, aim at the truth — are nevertheless, for the most part, [nullified], and there is found in them empty pretension and delusion.

This I have written, in brief, [in response to / against] the [nations' astronomers, quoting] the vision of the astronomers [of] Yeshayahu [chapter 47], "Let them stand now and save you, [the astrologers,] the stargazers… [foretelling] month by month what shall come upon you" [Yeshayahu 47:13]; [and thus] your soul [?] [shall be]. And it [becomes] a snare — all of it, as [in] the words of the book [of Scripture]; and I [derived it] from Micah, chapter 3, [verses 6–7]: "and [the sun shall go down] over the [prophets]," in his saying, "and the seers shall be ashamed, and the diviners confounded" [Micha 3:7]. So too Yeshayahu, [where] the prophet said, "who frustrates the signs of the false diviners, and makes the diviners mad" [cf. Yeshayahu 44:25]. And as [Radak] [wrote], on the root *qasam*, in these words: "This term includes every [craft]… [directed] to knowing the future, even by lots — [something] Chazal did not [permit]. They said [that we

know] one may not inquire by lots, from the verse '[you shall be] wholehearted [with the Lord your God]' [Devarim 18:13]..." [several clauses uncertain [?]]. And it also [accords] with [what is written] in the letters [Iggeros] of the Rambam [against astrology]: "...clear and refuting [proofs] in which there is no fault; I [have grounds to object] to these matters, and one should not cling to them, for 'only a fool believes everything' [Mishlei 14:15] — [namely] one who [seeks] to know [things reserved to] others" — end of the words of the Rambam, of blessed memory.

סימן רצ"ט — Siman 299 (printed 299 = רצ"ט; logically §300)

A small and slight notice concerning the matters of the twenty-eight camps [i.e., the twenty-eight mansions of the moon], which are called *mansiones lunae* [מאס יאנ'וס לונ"א — Latin, "mansions of the moon"].

Since, at the beginning, [God] gave power and dominion to the seven wandering stars [planets] over [the governance of] the lower world — therefore their revolutions and [their arrays hold sway]. The sun, which is more toward the middle [of the planetary order], [likewise holds sway] the more [as it were] within itself [?]; [it exercises no] judgment [independently], [but has] the greatest [power] and dominion, [moving] with the motion of the world, [more] than them all. And after the sun, the investigators wrote [of the moon], which [shines] upon the sphere of the earth more than all [the rest]: the Blessed Lord gave to it the [governance of...]; its revolution and course [determine] the lower world more than [the other] stars. [In sum,] all this I have filled out in [answering] them. Therefore know: [the astronomers] divided the sphere of the zodiac into twenty-eight parts, and called [each part] [a "mansion" — mansio], up to the [full] total of the twenty-eight mansions comprised in each period of the [return] of the moon [i.e., the sidereal month]. And they wrote — and this [holds] as it [the moon] goes each week and each [month] — [that they] prophesy, day by day, what will be. [several clauses effaced [?]]

סימן ש' — Siman 300 (printed 300 = ש'; logically §301)

On the aspects of the zodiac signs, which are called *aspectus* [אשפעקטוס — Latin, "aspects"].

The aspects of the zodiac signs are, in fact, found [to be of] four kinds: some of them are by opposition [ba-nochḥiyus]; some of them are [by sextile / "opened" — ba-mefulashim [?]]; some of them are quartile [reviʿiyim]; and some of them are trine [shelishiyim]. And now hear their rules:

The **aspects of opposition** are when two planets — or one planet and one [sign] — are [set] opposite and confronting one another in the sphere of the zodiac, at the utmost distance [180°], and are joined, in the mind, by a diameter or a single line, [issuing] from the one, passing through the center of the earth, [to] the other. [For example,] they are [in] Aries [and Libra? — reading uncertain], like… (that is to say, one planet stands in Aries and one planet stands in Libra); [and likewise:] Scorpio [opposite] [Taurus]; [Gemini opposite] Sagittarius [?]; Cancer opposite Capricorn; [Leo opposite] Aquarius; Virgo opposite Pisces. And when one of them rises upon the horizon, the one opposite to it sets; and so, conversely. This aspect [was reckoned], among the sages of the ancients, [to be the one that] estimates [its influence] upon [an evil] sign, and [it is one of] utter [enmity].

The **aspects of [sextile — the "opened"?]** are when the two signs, or one planet and one sign, are distant [60°? — the numeral is uncertain [?]] of the circle of the zodiac — [the] first square [?], which [holds] the power of a square [that has not] the four seasons [i.e., quarters]…

[the section continues; several readings uncertain — see report]

Diagram. At the foot of the left-hand column stands a circular figure: a heavy outer ring bearing text, and within it an interlaced star-polygon (straight chords crisscrossing the circle to connect points on an inner circle) — the classic *aspectarium*, illustrating how the aspects (opposition, trine, quartile, and sextile) link the points of the zodiac around the wheel. The outer ring carries, in a continuous band, the names of the twelve zodiacal signs. The legible labels are:

- Top of the ring: שור [Taurus] · התאומים [Gemini] · [סרטן / Cancer [?]] · [אריה / Leo [?]]
- Remaining signs continue around the lower part of the ring but are not legibly resolvable at this resolution (the band is worn and the lower arc is inverted): [Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces, Aries [?]]

Beneath the circle runs a row of small parenthetical reference-keys for the aspect-figures (heavily abraded); the legible fragments read: "… "…(ט"ס ק"ג) סימנו מבטי (ט"ח ע"ד) · "…(ת"כ ק"ד) כשלישי סימנו · "השני סימנו…" ·" [aspect]. The bracketed number-pairs appear to key the aspect-lines to reference values; the readings are uncertain. [— more than two rim/key labels flagged [?].]

שער י"ב — Gate 12 (continued and concluded)

סימן ש' [printed 300 = logical §301] — the astrological aspects (concluded)

(continuation from the preceding page; the aspectarium figure below illustrates the aspects among the zodiac points.)

The **trigonal (sextile) aspects** [מבטי המשולשים — the term as printed reads "triangular"; the definition given is the *sixth-part* = 60°]: this is when two planets, or one planet and one sign, are separated by a sixth of the zodiac circle. That is, when you divide the circle of the zodiac into six equal parts, the signs that then join together [by this aspect] are:

- Aries and Gemini
- Gemini and Leo
- Leo and Libra
- Libra and Sagittarius
- Sagittarius and Aquarius
- Aquarius and Aries

and likewise:

- Taurus and Cancer
- Cancer and Virgo
- Virgo and Scorpio
- Scorpio and Capricorn
- Capricorn and Pisces
- Pisces and Taurus [?]

Diagram. A circular aspectarium. The outer rim bears the twelve zodiacal signs running around the circle; within it is an interlocking star-polygon drawn in dashed lines, whose chords link the zodiac points to show how the aspects (opposition, quartile, trine, sextile) connect the signs. A pointing-hand woodcut (manicule) and an asterisk mark ✻ stand beside the figure in the margin, drawing the reader's attention to it.

- Outer rim (legible arc, upper portion): שור [Taurus] · תאומים [Gemini] · סרטן [Cancer] · אריה [Leo]
- Inner labels (partially legible): מזל טלה [the sign Aries]; מזל [?]

- Remaining rim and inner labels: illegible at this resolution [?]

And you should understand that all of this that we have said concerning the aspects and conjunctions of the signs applies to the *reckoned* signs on the sphere of the zodiac — that is, in the imagined division of the [zodiac] sphere into 360 equal parts — and **not** to the visible constellation-figures themselves as they appear in the firmament, which are not [of] equal size and have no fixed measure, as was explained above in Gate 5, §106 [שער ה' סי' ק"ו].

סימן ש"א [printed 301 = logical §302] — On the benefit of the aspects of the planets

The benefit found in the aspects of the planets and signs is for the practitioners of astrology [בעלי משפטי הכוכבים], who foretell the future. Roughly, they say that the planets **Saturn and Mars** are malefic; **Jupiter and Venus** are benefic; and the **Sun, Mercury, and Moon** are neutral. The opposition aspect and the quartile aspect are bad (as above), while the trine aspect and the sextile aspect are good — and the sextile aspect is better than the trine.

They also say: an aspect between two of the benefic planets indicates complete peace and love; an aspect between two of the malefic planets indicates strife and utter enmity; and an aspect between two neutral planets indicates peace and love, but not perfectly. An aspect of a good planet with a bad one — the good somewhat cancels the bad, and the bad likewise diminishes the good. A [good] aspect with a good planet is very good; a bad aspect with a bad planet is very bad; a neutral aspect with a neutral planet is [neutral]; a neutral aspect with a bad planet is [middling]; and a bad aspect with a good planet is not [wholly] bad.

Although we have no concern with these matters in this book of ours, nevertheless — since the student will find them in the words of the Sages, in Ibn Ezra [ראב"ע / Abraham Ibn Ezra], and in other books besides — [I explain] the matter of the opposition aspect, the trine aspect, and the quartile aspect, so that one may know something of these topics. I have noted this for the teachers mentioned, as a small annotation to this book of mine.

סימן ש"ב [printed 302 = logical §303] — On the benefit of the quadrature (quartile) combinations, and more

Know that, besides the benefit to the astrologers who [rely] upon the combinations of the aspects of the signs, there is in the **quadrature combinations** a special virtue and a useful knowledge. This is: when one sign is

setting [in the west], the sign at the [quartile] corner following it will be at mid-heaven above the earth; the sign standing after that, at the third corner of the quadrant, will be rising upon the eastern horizon; and the sign at the last corner will then be at mid-heaven beneath the earth.

An example: when Aries is setting, Cancer will be at mid-heaven above the earth, Libra will be rising on the eastern horizon, and Capricorn will be at mid-heaven beneath the earth. So too the matter with the other quadratures [signs].

All this holds **precisely** only for those living beneath the equinoctial line, or in the days of Nisan and Tishrei [the equinoxes] for the other inhabitants of the climes as well. But on the remaining days of the year, for those who dwell [away from the equator],

the [rule of the] direct sphere is already annulled [the pattern breaks], because of the [six] signs that are always above the horizon: some of the inhabitants of the climes will find four [ד'] signs on their eastern side from the meridian line, and [two] signs to the west — all according to the season and according to their nearness to the north or south, as was explained above in Gate 5, §101 [שער ה' סי' קנ"א].

סימן ש"ג [printed 303 = logical §304] — Nations, kingdoms, and many places in Europe, and under which zodiac sign each is placed

It is already known that all the nations beneath the heavens — the Blessed God has placed them all under the dominion of the stars (as above), so that each and every one of them is set under one of the twelve signs of the firmament. The sage **Ibn Ezra** [ראב"ע] wrote at length on this, on the verse "which He allotted to all the peoples under the whole heaven" [Devarim 4:19], and these are his words: "It is a settled thing that every single people has a known star and a known sign; and likewise each and every city has its sign." [reference and wording per the source, lightly abridged]

And so I saw fit to copy here from the books of the astronomers which of the twelve signs of the firmament certain kingdoms, provinces, and many places dwelling in the European quarter are set beneath — a matter made known through practical [observation], for [observers] watched, examined, and saw that when a given sign was in a favorable configuration, good fortune came to such-and-such a province or kingdom, and they found the matter reversed [when the configuration was ill]. And these are some of the particulars:

Aries [מזל טלה] — under its dominion are set: Germany [תגרמה], Greater Poland [גרושפולין / Grosspolen], White Russia [ווייס רוסין], Champagne [שמפנינן] [?], Ponterland [פונטר לנד] [?], Riss [ריס] [?], Riesen [ריסן] [?], Switzerland [שווייצר], Franconia [פרנקין לנד / Franken], Lorraine [לוטרינגן], Sweden [שווידן], Ireland [אירלנד], Burgos in Spain [בורגס שבספרד], Bologna [באנוניא] [?], Antokha [אנטוכא — Antioch?] [?], Zürich [צוריך], Lucerne [לוצערין], Würzburg [ווירצבורג], Metz [מעץ], Gniezno [גניזן / Gnesen], Leipzig [לייפציג], Karlstadt [קרל שטט], Parma [פארמא], Neumarkt [נוינגארטין] [?], Speyer [שפייאר].

Taurus [מזל שור] — under its dominion are set: the land of Germany [מדינת אשכנזי], France [צרפת], England [אנגלטירא], Lesser Poland [קליין פולין / Kleinpolen], Upper Burgundy [הוך ברגונדרא], Swabia [שוואבין], Upper Silesia [אוכר שלעזיא], Wisterich [ווישטריך] [?], Naples [נאפוליס], Florence [פלערענץ], Brunswick [ברונשוויג / Braunschweig], Austria [אויסטריך / Österreich], Kraków [קראקוב].

Gemini [מזל תאומים] — under its dominion are set: Egypt [מצרים], Armenia [ארמעניאן], Flanders [פלאנדרן], Brabant [בראבנד], Württemberg [ווירטן בורג], part of Lombardy [מקצת לומברדיאה], Wetzlar [ווצליר] [?], Nuremberg [נירן בורג / Nürnberg], Ansbach [אנשפך], Leuven/Löwen [לויבן], Mainz [מענץ], Bamberg [בומברג / Bamberg], Brieg [בריג] [?], Villach [וילאך], Cusingen [קוזינגין] [?], Hospart [הספארט] [?], London [לונדן], Kradukha [קראדוכא] [?], Rhein-Strom [רוין שטראם] [?], Zwickau [צוויקא].

Cancer [מזל סרטן] — under its dominion are set: the kingdom of Scotland [מלכות שאטן / שאטלנד] [?], Kargomer [כארגומר] [?], Prussia [פרוסין / Preussen], Holland [הולנד], Zeeland [זילינד] [?], Constantinople [קונשטאנטינאפל], Genidin [גנידיין] [?], Genoa [יעגנובא] [?], Lucca [לוקא], Milan [מילנד / Mailand], Vicenza [ווינצענץ], Breren [ברערין] [?], Trier [טריירי], Lübeck [לויבק], Magdeburg [מאדיבורג], Görlitz [גירליץ], Freistadt/Prwiskmark [פרויסקמרק] [?], Brandenburg [בראנדיבורג].

Leo [מזל אריה] — under its dominion are set: Italy [וועלש לנד / Welschland], Sicily [ציצילע], Padua [פאטרעם] [?], Bohemia [פוהם / Böhmen] [?], Prague [פראג], Ulm [אולם], Koblenz [קאבליענץ], Linz [לינץ], Krems [קרעמז], Rome [רומה], Rabinomechli [ראבינו מעחלי] [?], Weit-burg [ווייט בורג] [?].

Virgo [מזל בתולה] — under its dominion are set: the land of the Greeks [ארץ היונים], Africa [אפריקא], Carinthia [קערנטן / Kärnten], Croatia [קראבאטן], Babylon [בבל], Lower Silesia [נידר שלעזיא], Etschland [עטשלנד] [?], Rineka [רינקא] [?], Radim [ראדים] [?], Jerusalem [ירושלים], Pavia [פאביא], Paris [פאריס], Leuven [לויבן], London [לונדון], Basel [באזל], Erfurt [ער פארט], Breslau [כרעסלוויא / Wrocław], Heidelberg [היילדלבורג].

Libra [מזל מאזנים] — under its dominion are set: Austria [איסטרייך], Elwim [עלוים] [?], Litland [ליטלאנד] [?], Savoy [סאפויע], Strasbourg [שטראס בורג], Vienna [וויען], Livonia [ליספלאנד / Liefland] [?], Raustreich [ראושטרייך] [?], Frankfurt [ורנקכורט / Frankfurt] [?], Dmin [דמין] [?], Speyer [שפייאר], Schwäbisch Hall [שוועבש האלי], Heilbronn [היילפרן], Wimpken [וויספכן] [?], Nnerwengin [ננרוועגין] [?], West-Schweden [ווימשט שווידן] [?], Katolningen [קאטולנינען] [?], Waldkirch [וועלדרקירך], Lizer-ban [ליזר באן] [?], Antwerp [אנטווארף], Switzerland [שוויצר].

Scorpio [מזל עקרב] — under its dominion are set: Grwengin [גרוועגין] [?], West-Schweden [ווישט שווידן] [?], Vienna [וויאן], Katolingen [קאטולינגן] [?], Auberen [אויברן] [?], Bavaria [פייארן / Bayern], Alkordra [אלקורדרא] [?], Brixen [בריקסן], Mwinben [מווינבן] [?], Vian-de-Provence [וויאן דפראבבענץ] [?], Waal-enz [וואל ענץ] [?], Dehtstfnia [דהטשטפניא] [?], Danzig [דנציק].

Sagittarius [מזל קשת] — under its dominion are set: Spain [שפאניא], Hungary [אונגרין / Ungarn], Moravia [מעהרין / Mähren], Wegdern [וועגדרן] [?], Waltengedra [וואלטענגדרא] [?], Meissen [and] Cologne [מייסן קאלוניא], Aubn [אויבען] [?], Rothenburg [רוטין בערג], Stuttgart [שטרוס גארטין] [?], Kashez [קאשעז] [?], Avignon [אבניאן] [?], Shaltut [שאלטוט] [?], Deshpnia-guta [דשפניא גוטא] [?].

Capricorn [מזל גדי] — under its dominion are set: Cologne [כולן / Köln], Nidriar [נידריאר] [?], Sachsen/Hessen [זקסן העכן] [?], Wirinkan [ווירינקאן] [?], Styria [שטיירמרק / Steiermark], Altenburg [אלטנבורג], Gulin [גולין] [?], Cleves [קליווא / Kleve], Bergen [בערגן], Yegnet-mepl [יעגנט מעפל] [?], Augsburg [אונשבורג], Brandenburg [ברנדיבורג], Kashingin [קאשינגין] [?], Ulm [אולם], Vilna in Lithuania [ווילנא דליטא].

Aquarius [מזל דלי] — under its dominion are set: Muscovy [מאסקוויא / Moscow], [?], Rusirwesn [רוסירווסן] [?], South Sweden [זוד שווידן], Wallachia [וואלכייא], Rustreussen [רושטרויסן] [?], Wischpolin [ווישפולין] [?], Hamburg [המב רג], Bremen [ברעמין], Salzburg [זאלבורג], Trier [טריר], Monpiror [מונפירור] [?], Pisa [פיסא].

Pisces [מזל דגים] — under its dominion are set: Portugal [פורטיגאל], Normandy [נורמנדיאה], [?], Regensburg [ווישטריך רעגנשפורג / Regensburg], Wirdmesh [ווירדמש] [?], Alessandria [אלבסנדריאה], Farenz [פארענץ] [?].

סימן ש"ד [printed 304 = logical §305] — Whether the Jewish nation is placed under the dominion of the stars

And as for us, the holy congregation of Israel — are we set under the dominion of the stars, or not? This matter requires great study and reflection, and there is

much [to say]. One finds in it differing opinions and disputes among the earlier and later authorities.

We have already found in this a great dispute among our Sages, of blessed memory, in [tractate] Shabbos [156a — the reference is somewhat abraded]. For it is taught there [Aramaic: as we learn there]: "It was stated — R. Chanina said: A [person's] constellation makes one wise, and a constellation makes one wealthy, and there **is** a constellation [i.e. mazal] for Israel [יש מזל לישראל]. And R. Yochanan said: There is **no** constellation for Israel [אין מזל לישראל]." And so they said there in the name of R. Yehuda in the name of Rav, and likewise from Shmuel, from R. Akiva, and from Rav Nachman bar Yitzchak — all of them agreed that there is no constellation for Israel [אין מזל לישראל]. (See there in Rashi's commentary [ועיין שם בפירש"י].)

And Don Isaac **Abarbanel** [דון יצחק אברבנאל] has already expounded on this at great length, in extensive and wide-ranging words. I have seen fit to bring out the essence of his intent in brief words, and to arrange it here [but the abridgment itself is not reproduced on this page].

סימן ש"ה [printed 305 = logical §306] — The names of the [forty-eight] figures of the heavens, and the order of their stars

We have already explained from the outset, in Gate 5, §[?] [כסי' ק"ן — number garbled], that the ancients agreed [to picture] the twelve signs of the firmament [by drawing], upon each and every one of the twelve signs of the firmament, [lines] from this star to that star and from that star to another, so as to [form] upon it the figure they agreed upon. And just as they did with these [zodiacal] figures, so too they did with the rest of the stars of the heavens — until they gave [names] to those stars: "the Great Bear," and another cluster "the barking Dog," "the flying Eagle" [or "the soaring vulture"], "the Sea-Fish," "the Triangle," and others.

Those they added beyond the twelve signs number **thirty-six** [שלשים ושש? — as printed, garbled], and [with the twelve] they made **forty-eight figures** [מ"ח צורות] in all. Now the thirty-six figures over against [the zodiac] are set out [here]. I saw fit to set forth in this place the names of the northern [figures] and the [southern] figures, and I bring them out by the number of their host; and these they are:

The Northern Figures [צורת הצפונית]

Table reads right-to-left in source; the middle column gives the number of stars Ptolemy assigns each figure. Numerals are in small, degraded type — cells I could not read with confidence are marked `[?]`.

#	Figure (Hebrew)	English	Stars
(1) א	הדוב הקטן	the Little Bear [Ursa Minor]	(7) ז
(2) ב	הדוב הגדול	the Great Bear [Ursa Major]	[?]
(3) ג	התנין	the Dragon [Draco]	(31) לא
(4) ד	בעלת הלהב	the flame-bearer [Cepheus?]	(11) יא
(5) ה	הכלב הנובח [?]	the barking Dog [?]	[?]
(6) ו	הסנזר השמאלית [?]	the left [crown?] [Corona Borealis?]	(8) ח
(7) ז	ההולך על ארכובו	the one going upon his knee [Hercules]	[?]
(8) ח	הנשר הנופל	the falling Eagle/Vulture [Lyra]	(10) י
(9) ט	התרנגולת	the Hen [Cygnus]	[?]
(10) י	היושבת על כסא	the one seated on a throne [Cassiopeia]	[?]
(11) יא	הנושא ראש השטן	the bearer of the demon's head [Perseus]	[?]
(12) יב	הרואה שבידו רסן	the one holding a rein [Auriga]	[?]
(13) יג	עוצרת החיה	the restrainer of the beast [Ophiuchus]	[?]
(14) יד	החיה	the beast/serpent [Serpens]	[?]
(15) טו	השסן [?]	[the Arrow? — Sagitta] [?]	[?]
(16) טז	הנשר המעופף	the flying Eagle [Aquila]	[?]
(17) יז	דגי הים [?]	the Sea-Fish [Delphinus]	[?]
(18) יח	ראש הסוס	the Horse's Head [Equuleus]	[?]
(19) יט	הכוס בעל כנפים [?]	the winged [Horse]	[?]

#	Figure (Hebrew)	English	Stars
		[Pegasus]	
(20) ך	האשה [?]	the [chained] Woman [Andromeda]	[?]
(21) כא	המשולש	the Triangle [Triangulum]	[?]

The Southern Figures [צורת הדרומית]

Table reads right-to-left in source. Names are heavily garbled by the compositor and anchored to their zodiacal reference (e.g. "under Taurus," "under Gemini"). Cells not read with confidence are [?].

#	Figure (Hebrew, as printed)	Note
(1) א	כמדים לריגוסט [?]	[?]
(2) ב	כשור כגנור [?]	under Taurus [?]
(3) ג	בשור כנקל [?]	under Taurus [?]
(4) ד	בשור מרכנת [?]	under Taurus [?]
(5) ה	תאומים סכלב הגדול	Gemini — the Great Dog [Canis Major]
(6) ו	התאומים סכלב סקטן	Gemini — the Little Dog [Canis Minor]
(7) ז	כרטן ספסיבש [?]	under Cancer [?]
(8) ח	כרטן סקיס [?]	under Cancer [?]
(9) ט	אריה סכום [?]	under Leo [?]
(10) י	בתולה סעלב [?]	under Virgo [?]
(11) יא	בתולה פסיס כנשאך [?]	under Virgo [?]
(12) יב	הזאב	the Wolf [Lupus]
(13) יג	עקרב סמחקס [?]	under Scorpio [?]
(14) יד	קשת כזר כדלומי [?]	under Sagittarius [?]
(15) טו	גדי כדנ טדלומי [?]	under Capricorn [?]

The Conclusion of the Book [בהתימות / החתימה]

The conclusion of this book of mine. I have news to report [חדשות אני מגיד? — verb uncertain]: In the year **5360** [ש"ס לאלף הששי = 360 of the sixth millennium; 5360 AM − 3760 = 1600 CE], our lord the exalted Emperor **Rudolf** [רודאלפו"ס — Rudolf II], may his glory be exalted — since he was filled with understanding and

abundant knowledge of the science of astronomy, and loved and honored the sages and provided for them — sent to the land of **Denmark** [דעני מרק / Dänemark] and summoned the eminent sage, the great investigator in the science of astronomy beyond all who had preceded him, one of the nobles of the land among his own people, called **Tycho Brahe** [טיח"א בראה"י]. The Emperor settled him in the fortress-castle called **Benátky** [בינאטק], five parasangs from the royal city of **Prague**, and there [Tycho] secluded himself with his associates.

[The Emperor] fixed and granted him three thousand thaler [טאלר] every year, together with bread, wine, and provision, apart from many other benefices and gifts. There in that place [Tycho] sat with **twelve men**, all of them sages, knowledgeable in the science of the stars and investigators in astronomy, [equipped] with their great and extraordinary observing instruments, such as no eye had ever seen. The Emperor built him there **thirteen chambers** in a single row, in each and every chamber a special instrument by which they observed the position and the courses of all the wandering stars [planets] and most of the fixed stars. Continually, throughout all the days of the year, day by day, they watched and made exact measurements, writing down in a book the course and position of the Sun in its sphere — in longitude and in latitude, [its height in] the firmament and its distance from the center of the earth. So too they did every night: investigating and measuring precisely each and every one of the six wandering stars, the position of each in longitude, latitude, and altitude in the firmament, and the ratio of the nearness and distance of each from the globe of the earth; and likewise most of the fixed stars, the course and position of each of them.

And I too, the writer, was there — [a specific number of] times [the source prints a gematria numeral here — reads (50) נ' or (3) ג' (?), not the word "כמה"; Stage-5], each time five consecutive days — and I dwelt among them in their chambers of observation. I saw the work that was being done: great and wondrous things, not only concerning the wandering stars but also concerning most of the fixed stars. [?] When it was named — as each star came to the meridian at midnight, [the measurement] was carried out steadily upon them by means of three kinds of instruments, at each instrument two sages seated, and everything at once written down in a book. And every star [that came] to the meridian at midnight, and the fine [reckoning] of the hour to which this belonged — [Tycho] had a wondrous novel [device] of hours [?]. In the clear air, faithfully, they exerted themselves and were exacting to a degree such as we have not seen or heard in our days — nor did our fathers recount it to us, nor have we found it

written in any book, whether among Israel or, to distinguish them, among [the nations] that have been [before us].

And the purpose of what has been recounted is to open the ear of the reader to the cause of the great and mighty extent of the investigations into the courses of the stars that the great, upright investigator, the aforementioned **Tycho Brahe** [טיח"א בראה"י], weighed and searched out — and how he altered many things from the foundations laid down by **Ptolemy** [בטלמיוס], all by [sound] reasoning; and further, [how he] tasted new matters, exceedingly wondrous things, which the ancients never conceived at all. Four of his novel achievements I shall mention here as a small and brief annotation, in wondrous concision:

1. He demonstrated by his tokens [observations] the matters [pertaining to] a **fixed sphere and a moving star** [גלגל קבוע וכוכב חוזר] — and how greatly his words are acceptable to the intellect. We already disclosed a little of this in Gate 1, §15 [בשער הראשון בסי' ט"ו].

2. That the **center of the Sun has shifted** over the length of time, [moving] beneath the line of [the ecliptic? — קו הקדרות, term garbled, [?]].

3. He demonstrated, by clear proof from three of the [wandering] stars — [including] Venus [נוגה] — that in their motions they do **not** [always] revolve about the globe of the world; rather, [they revolve] only in what they turn each day, by reason of the uppermost [diurnal] motion alone.

4. That, as regards the shells [orbs] of the five planets [שצ"מ = Saturn, Jupiter, Mars, [Venus,] Mercury], the **center of the earth is not their center** — not to speak of the deferent or the inclined sphere; indeed, even the highest sphere [does not have] the earth's center as center for any of them — only for the spheres of the Sun and the Moon [is the earth the center]. But from [the evidence of] the other five wandering stars, the **center of the Sun itself is their center**: and in his view the Sun forever sits, as it were, in the middle, **like a king seated among his people who surround him as is their custom**; and none of the wandering stars ever approaches or recedes from the center of the Sun from time to time — not even to say [that it varies] over all the days of the world. This, which none of the ancient sages ever depicted or [so much as] imagined at all, etc.

And [with regard to] these last matters, it is somewhat hard to explain them to students as fitting, for the scribe's pen is too weak to depict it and set it upon paper properly. Yet I have with me **diagrams of the spheres from the lord**

Tycho [חבורי גלגלים מן השר טיח"א], the aforementioned, by which every discerning student may understand the true nature of these matters as fitting.

Completed [סליק] — Friday, the 8th of Av, [5]373 by the minor reckoning [שע"ג לפ"ק = 5373 AM − 3760 = 1613 CE]. **Finished** [סליק].

[This leaf is the scanning institution's cover card, not part of the book: National Library of Israel logo, with the Hebrew notice below.] ספר זה נסרק על ידי הספרייה הלאומית [Hebrew: "This book was scanned by the National Library."]

נעים ונחמד — *Na'im ve-Nechmad* (David Gans)

[Hebrew title block, printed p.186:]

ספר [*Sefer* — "The Book"]

נעים ונחמד [*Na'im ve-Nechmad* — "Delightful and Desirable"; the astronomical work of David Gans, conventionally cited as *Nechmad ve-Na'im*. The Latin body below renders the two words as *iucundissimus et desideratissimus*.]

מתמים רעים וכו' [?] [Hebrew subtitle line, uncertain reading; ends with וכו׳ "etc.", indicating a truncated scriptural phrase]

WHAT IT CONTAINS is here reviewed by Dr. Johann Christian Hebenstreit [Johann Christian Hebenstreit], in the University of Leipzig [Lipsiensi] Public Professor of the Sacred Language [Lingvae Sanctae P.P. = *Professor Publicus*].

[Printed p.1 — source]

The book bearing this title is called "most delightful and most desirable," and the work is praised as elegant, written in a polished and flowing style. It treats of astronomy — of the consecration or establishment of the new moon [*de consecratione seu constitutione nouilunii*], and of how the first day of any given new moon is to be determined; of the measurement of the stars [*de dimensione stellarum*]; and it adds, moreover, figures of the instruments that those skilled in the art customarily use to observe these things. It deals as well with the climes [*de climatibus*], for the understanding of geographical maps, and with other matters bearing on the subject.

Its author is said to be that same man who wrote the very well-known historical book צמח דוד [*Tzemach David*, "The Sprout of David"], and who is also author of the book מאור הקטן [*Ma'or ha-Katan*, "The Lesser Light"] and of הפרוזדור [*ha-Prozdor* — Greek πρόθυρον [Greek: prothyron, "vestibule," i.e. the forecourt or

atrium]; whether either of these two has in fact been published is still unknown to me] — namely David Gans of Prague [David Gans, Pragensis].

The title indicates that this work was preserved and lay hidden among the Jews from the year of the World 5373, of Christ 1613. That year — and its month Av [Abh], which in our calendar is July, the 5th day of the month, the 7th day of the week — the author himself declares, at the end, to have been the birth-date of his composition. And the late Wolf [Johann Christoph Wolf], in his *Bibliotheca Hebraea*, Part III, no. 481, p. 181, recorded that this very same year was the year of the author Gans's death.

It has now, however, been published in the year just elapsed, which was the year of the World 5505 — a figure the editor indicates in Hebrew letters through the final words of the passage "Lift up your eyes on high, and see who has created these things" (Isaiah XL, 26) — of Christ 1743; and indeed at Jessnitz [Iesnitii], from the printing house of Israel Bar Abraham, by the labor and diligence of Joel son of Jekuthiel [Joel ben Jekuthiel], אב בית דין [*Av Beit Din*], that is, Head of the rabbinical court of the synagogue of Osterlic [Osterlicensis (?)] in Bohemia, a native of Gloga-

[Printed p.2 — source]

—gau [Glogau, Głogów]; but at the expense of Ber Hess of Halberstadt [Ber Hess, Halberstadiensis]. And these are the things that the book's title-inscription contains.

There follows the Editor's preface, which he calls התנצלות [*Hitnatzlut*], that is, an excuse and apology, in which he sets out his reasons for undertaking the edition he has taken upon himself.

The work itself has prefixed to it the הקדמה [*Hakdamah*], that is, the preface of the author Gans, in which he treats of the discoverers and developers of the science of astronomy. In the first place he notes that the first of all men skilled in astronomy is found in Scripture to be Abraham, on the testimony of the Talmud, Tractate Shabbos [Tr. Schabbath], last chapter, at the end: there Abraham, conversing with God, says that from his astronomy he sees that he is not fit to father a son, and God answered him, "Go out from your astronomy; for the destinies of Israel do not depend on the stars." After Abraham, the sons of Issachar were renowned for skill in the stars, for 1 Chronicles XII, 32 [1 Paral. XII, 32] affirms of them that in the time of David there were among them "men skilled in the times." After these, Scripture sets forth Solomon as pre-eminent in this science (1 Kings III, 12 and V, 11); and that his wisdom, praised in these passages,

is to be understood specifically of astronomy, he proves from the apocryphal book called the *Wisdom of Solomon* [*Sapientia Salomonis*], ch. VII, 17, 18, 19.

Next, he says that R. Nachman [Nachmanides] affirms the same about Solomon in his preface to the Pentateuch, and that Nachmanides appeals to that same testimony of the apocryphal book, and also to the Tanchuma, and so forth.

Further, from the Talmud he brings forward R. Eliezer, surnamed the Great, son of Hyrcanus [R. Eliezer ben Hyrcanus] (on whom see the late Wolf [Johann Christoph Wolf], *Bibliotheca Hebraea*, Part I, no. 271, p. 172), whose astronomical skill he says is evident from the many wise sayings of his that are contained in the tractate of the Talmud named after him "Pirke," that is, the Chapters of R. Eliezer [*Pirkei de-Rabbi Eliezer*]. Likewise R. Gamaliel [Rabban Gamaliel], who, on the testimony of Tractate Rosh Hashanah [Tr. Rosch Haschana] c. 100 [?], is said to have had a figure upon a tablet and on the wall, by which, demonstrating it, he taught the ignorant. And also two celebrated arithmeticians and astronomers in the time of R. Akiva [R. Akibhae], namely R. Eliezer son of Chasda [as printed] and R. Yochanan son of Gadgada [as printed], and so forth.

He adds that the ancestors of the Jews had settled, with such certainty, the solar year, its ἐμβολισμοῖς [Greek: embolismois, "intercalations"] — that is, intercalations — and the Tekufot [*Tekuphis*], that is, the solstices and equinoxes, that their tables still answer today, and there is no need to think about corrections — corrections which the Non-Jews are obliged to make from time to time (העכו"ם [*ha-Akum*], which some read עובדי כוכבים ומזלים [*ovdei kochavim u-mazalot*, "worshippers of stars and constellations"], others עובדי כריסטוס ומריה [*ovdei Christos u-Maria*, "worshippers of Christ and Mary"]). And those very people—

— those sages, whether gentiles or Christians, praise and marvel at this precise exactness of the Jews in calculation.

He admits, however, that the Talmudic doctors' knowledge of this art was not especially refined, since they applied themselves more to the Law than to such subjects; and he confirms this on the testimony of Maimonides [Maimonides] in the *Guide of the Perplexed* [*More Nevukhim*] III.14, of *Genesis Rabbah* [*Bereishis Rabbah*], and of R. Moses Isserles [Moses Isserles] in *Toras ha-Olah* (on whom see J. C. Wolf, *Bibliotheca Hebraea* [*Bibliotheca Hebraea*] Part I, no. 1515, p. 803), Part I, ch. 2.

He adds, moreover, from among the more recent astronomers of his own nation: R. Zerachiah [Zerachiah HaLevi], author of מאור [*Ma'or*, "the Luminary"] (perhaps

the same man whom Wolf records, *op. cit.* Part I, no. 582, p. 361); R. Avraham b. Chiya [Abraham bar Ḥiyya] (see Wolf, *op. cit.* nos. 76, 77, p. 54); R. Isaac Israeli b. Joseph [Isaac Israeli] (Wolf, *Bibliotheca op. cit.* no. 1213, p. 663); and R. Judah Loew b. Bezalel [Judah Loew, the Maharal] of Prague, his own contemporary (Wolf, *op. cit.* no. 700, p. 418).

After these he praises the most celebrated writers on astronomy of his own people: Maimonides in the *Yad ha-Chazakah*, tractate קדוש החודש [*Kiddush ha-Chodesh*, "Sanctification of the New Moon"], on the determination of the new moon; R. Avraham Ibn Ezra [Abraham Ibn Ezra] (of whose eight books on astronomy, ס' מאצטגנינת [*Sifrei ha-Itztagninut*, "books of astrology"], see J. C. Wolf, *Bibliotheca* Part I, no. 110, p. 81); R. Avraham b. R. Chiya, who wrote צורת הארץ [*Tzurat ha-Aretz*], on the figure of the earth (Wolf, *Bibliotheca op. cit.* no. 75, p. 52); R. Isaac Israeli b. Joseph, author of the book יסוד עולם [*Yesod Olam*], "the foundation of the world," and שער השמים [*Sha'ar ha-Shamayim*], "the gate of heaven" (Wolf, *op. cit.* no. 1213, pp. 654, 656); and R. Levi b. Gershon [Gersonides], who published מלחמות ה' [*Milchamot HaShem*], "the Wars of the Lord" (Wolf, *op. cit.* no. 1348, p. 728), who also cites that author's ספר תבונית [*Sefer Tevunit* [?], apparently for *Sefer Tekhunah*], an astronomical work compiled from various ancient writings, p. 729.

He then traces the transmission of this science from the very beginning of the world down to his own times. He attributes outstanding skill in astronomy even to Adam himself, on the authority of Joseph ben Gorion [Josippon]. Likewise he states that Josippon reports of Abraham that, when he was living as an exile in Egypt because of the famine, he taught arithmetic and astronomy to the learned men and magicians of that nation within a few days; and he directs the reader to compare tractate *Shabbos*, last chapter. From Abraham, he says, his son and grandson learned this science; and in those same days lived Job, a most excellent astronomer — as appears from many passages of his book, for example ch. 9, v. 9, where he speaks of Arcturus and Orion, and ch. 38, vv. 31–33: words that God, to make him skilled in astronomy, would have addressed to him in vain had he been ignorant of that science.

He teaches further that the Egyptians learned the art of numbering and measuring, joined with astronomy, from Jacob and his sons, over the rather long

period of their exile (since Abraham, as he had noted above, had within the few days of his sojourn taught only their magicians this art), and that they cultivated it more fully from that time on.

He confirms this by the testimony of the ancient sages of his own nation, who in many places make mention of Pharaoh's astronomy and report that the Egyptians excelled all others in this art — and this for three reasons: (1) because they had learned it from Abraham and his descendants; (2) because they had great need of that science of measuring and numbering on account of the flooding of the Nile, so that they might mark out the boundaries — obliterated by the silt heaped over the fields — and restore to each his own plots of land; and from this science of measuring the land they went on to measure the planets and the other stars as well, whence it came about that geometry, as the general term for measuring, included astronomy too; (3) because, as regards astronomy, in no other region could astronomers observe the stars in so continuous and unbroken a series as the Egyptians could in their own. For Egypt alone enjoys a clear sky throughout the whole year, while all other lands are frequently overcast with clouds and rains that hinder continuous observation of the stars. And he wishes Deut. 11:10ff. to be compared here.

And it is for this very reason, he says, that Holy Scripture prefers the wisdom of the Egyptians to that of all others, when it declares Solomon [Solomon] wiser than the Egyptians themselves (1 Kings 5:10); and the commentators understand that wisdom which is there praised in Solomon, by which he surpassed them, to be the astronomy of the Egyptians.

He says that this discipline passed from the Egyptians to the Greeks, among whom, around the time of the Trojan War — which he himself thinks fell in the age of the Israelite Judges — there flourished קידון [*Cidon*], the discoverer of the 48 celestial constellations, and סירון [*Siron*], in the time of Daniel and Cyrus [Cyrus]; likewise סילום מיסיליום [*Silus Messilius*], born in the Greek city ויניצו [*Venezo*] (names either unknown to history today and not transmitted to us, or else strangely corrupted). He makes this last man the discoverer and first describer of the causes of solar and lunar eclipses. To him he subjoins Solon [Solon]; and to Solon two men of great renown, Pythagoras [Pythagoras] and קאיוס אטפירוס [*Caium Atperum* — "Gaius Atperus," or however it is to be read] — both of whom, he says, admitted that they had received that wisdom of theirs from the Jews. And he adds that all of these came forth from Athens, the chief city of Greece and seat of the wise, and that this city too is mentioned in the Talmud, tractates *Niddah* and *Berakhot*, under the name אתונא [*Athuna*, Athens].

He continues that the Chaldeans received this doctrine from the Egyptians and Greeks; and among the most ancient and celebrated of the Chaldeans he names two, טיאוקדוס [*Ti'okdos* [?]] and ארימולוס [*Arimolos* [?]], who lived about fifty years

before Alexander of Macedon [Alexander the Great], around the year of the world 3400, and who were, so far as is established, the first to have observed the fixed stars accurately. And he says the Talmud, tractate *Shabbos*, last chapter, bears witness to the excellence of the Chaldeans in this art.

He notes that the writings of these men are extremely rare and have survived only in the cabinets of a few scholars. But now, he says, he wishes to record also those who lived from the time of the First Temple down to the present day and whose writings have reached us. Among these he first names Euclid [Euclid], a most acute man who had no one more learned before or after him; he wrote a book called, after his own name, the *Euclid* [*Elements*], in which — like Jacob's ladder — standing on the earth, he touched heaven itself (Gen. 28:12). This Euclid too, he says, was an Athenian and lived in the time of Mordecai and Esther [Esther], as the *Sefer Yuchasin* [*Sefer Yuḥasin*] f. 13 attests, around the year of the world 3400. After him comes Archimedes [Archimedes], whose writings have likewise reached us — so skilled an arithmetician and geometer that he determined how many grains of sand the whole world would hold, from the center of the earth up to the eighth sphere of heaven; and he says Archimedes lived at Syracuse around the year of the world 3500. He adds that by this same Archimedes another distinguished mathematician of his time is praised, אריסטיקוס סיריוס [*Aristikos Sirios* [?], possibly Aristarchus of Samos]. To him he joins the one mentioned above, אברכס [*Abrakhas*, i.e. Hipparchus [Hipparchus]], whom the Greeks call *Cypricus* [?] — a man who, on Ptolemy's testimony, surpassed all before him in diligence and wisdom, and who determined the hours, moments, minutes, and so forth; his many further services to astronomy are recorded in *Yuchasin* f. 17 and in *Me'or Enayim* [*Me'or Einayim*] ch. 40. He reports that this man lived in the Greek city of Rhodes. In the time of Julius Caesar [Julius Caesar], he continues, two eminent men were renowned, one called קלופו [*Clopu* [?]], the other סוסיגעס [*Sosigenes* — Sosigenes, Pliny [Pliny], *Natural History* XVIII, ch. 25 [?]]; and Caesar made use of them in fixing the Julian year. This reform, he says, was made in the year of the world 3534, in the time of the Hasmoneans, or in the year of the Contracts [the Seleucid era] — for so they call the era introduced in honor and memory of Alexander the Great (see the explanation drawn from *Tzemach David* [*Tzemach David*] in Voisin's [Joseph de Voisin] notes to the preface of Raymund Martini's [Raymund Martini] *Pugio Fidei* [*Pugio Fidei*], p. 63f.) — namely the year 186; 227 after the building of the Second Temple, and 194 before its destruction, on the testimony of *Yuchasin* f. 117. The next place the author assigns to

Ptolemy [Claudius Ptolemy], a citizen of Alexandria in Egypt, author of the book *Almagest* [*Almagest*], than whom, he affirms, no one before him was more skilled in this art; and he says Ptolemy lived in the time of Antoninus Pius [Antoninus Pius], in the year of the world 3900, the year of Christ 101. This Ptolemy, he judges, undoubtedly gained much from the Jews, very many of whom, most learned men, then dwelt at Alexandria. For there was there a synagogue famous for its 70 golden seats, which as many most erudite rabbis adorned (on the enviable glories of this synagogue see Vitringa [Campegius Vitringa], *De Synagoga Vetere* Book I, ch. 14, p. 252). Ptolemy's proper name, he says, was Claudius, while his other name was a patronymic cognomen, taken from the Ptolemies, the kings of Egypt after Alexander the Great, from whose lineage he traced his origin — though the Romans had wrested that kingdom from them by force of arms 170 years earlier. Hence Tycho Brahe [Tycho Brahe] said, in praise of this Ptolemy: The Romans indeed took the Egyptian kingdom from his ancestors, yet they themselves gradually went to ruin; whereas he, through his own wisdom, gained another kingdom a thousand times more excellent. For he subjected to himself all three parts of the earth then known — not with the sword's point, but with the tip of the writing-pen; indeed, not content with these, he ascended even to the eighth sphere of heaven, and so became king of both the lowest and the highest regions.

He continues that al-Battānī [al-Battānī], the Arab, followed in this Ptolemy's footsteps; he asserts that al-Battānī's tables are known and in received use down to the present day, and that Maimonides himself, in the *Halakhot* on the determination of the new moon, follows his tables in many points. These tables, he says, were completed in the year of Christ 980, in the year of the world 4640, and 740 years after Ptolemy's labors. Finally he reckons among these Alfonso [Alfonso X], king of Spain and Sicily, who established a college of learned men of this art to investigate its principles further, spending to this end four hundred thousand gold pieces; the origin of these tables fell in the year of the world 5015, the year of Christ 1225. Their author, he reports, is said to be a Jew, R. Isaac b. Sid [Isaac ibn Sid], per *Yuchasin* f. 132, in the year of the world 5011; and from Alfonso they are still today called the *Alphonsine Tables* [*Alphonsine Tables*]. These were translated from Spanish into Hebrew, by Alfonso's order, by R. Jacob Alkarsi [Jacob Alkarsi] in the year of the world 5020; and he himself — Gans, the author of the preface — turned some of them from Hebrew into German for Tycho Brahe.

Bringing up the rear is Nicolaus Copernicus the Prussian [Nicolaus Copernicus], of whom Gans declares that, from the days of Ptolemy [Claudius] onward, no one in this art has been his equal or his superior. Copernicus, he says, demonstrated

that the globe of the earth is in perpetual rotation — though this was no discovery original or new to him, but had already been known long before him to Pythagoras, on the testimony of the author of the *Book of the Heavens and the World* [Sefer ha-Shamayim ve-ha-Olam] (by which Gans doubtless means those books that above, in Part I, he had cited as written by the author Isaac the Israelite [Isaac Israeli]), Part II, *Michlal* IV. And on this subject — namely, the revolutions of the celestial orbs — Copernicus published a profoundly learned book, in A.D. 1500, and died in his homeland in 1543, [Anno Mundi] 5301.

From this, he infers, it is plainly evident that the science of astronomy passed not from the gentiles to the Jews, but from the Jews to the gentiles — at the time, that is, when the Jews were subjected to the rule of the nations. In support of this opinion he cites the *Moreh* [Nevukhim; Maimonides, *Guide of the Perplexed*], Part I, ch. 71, and the author of *Derech Emunah*, as well as the book *Me'or Einayim*, chs. 2 and 8.

He appeals also to the learning of King Solomon. Solomon's mathematical writings no longer survive under his name, yet it could well have happened that they fell into the hands of the gentiles, who — suppressing the name of the true author — claimed them as their own. To this end he cites the book *Shevilei Emunah* [Scheile Emuna] and its *Netiv* VIII (the author is R. Meir Aldabi, per J. C. Wolf[f] [Johann Christoph Wolf], *Bibliotheca* [Hebraea], Part I, no. 1369, p. 744). And he holds that this loss of the Jews' treasures is to be ascribed to their exiles and to their dispersion across all four quarters of the world.

Since this is so, he concludes, it is no disgrace to the Jews to profit today from the writings of non-Jews and to learn astronomy from them — just as the wisest of the Ancestors learned plowing and the planting of trees and vines from the Amorites [Amoraei], and laid it down that God is to be praised if even from a gentile a word of wisdom is heard. Hence the despisers of this most noble science are not to be heeded. These he sorts into two classes. The first are those who reject the whole art as uncertain and deceptive, and who keep insisting that it is mere conjecture, since it is not granted to mortals to ascend the heavens and probe the stars. The second are those who do indeed grant that this science enjoys a certainty of its own, but who nonetheless shamelessly cry out that the labor spent upon it has no value and no benefit.

In order to answer these objectors, he finally, toward the end, adduces a fivefold use of astronomy. The first, he says, is that through it we are led to know the omnipotence of Him at whose word the world was made — compare Psalm 19:2 and Kimchi [David Kimchi, Radak] on that passage. The second: that by way of

causality we may reason from effect to first cause, from things moved to the first mover — after the example of Abraham, who, the Rabbis relate, on beholding the palace of heaven, said: "this palace cannot be without a Lord." For it does not suffice merely to believe that God exists; one must also know it demonstratively — a knowledge that the contemplation of the stars most surely produces — and the sacred writings in many places require the knowledge of God. The third: that the foundation of the intercalations be learned; for unless these are properly grasped and accurately observed, no affirmative precept concerning the celebration — each at its own time — of the festivals, of Passover, and of the remaining observances that depend on these, can be rightly kept. Nor is this science of intercalation to be thought of little worth, as though it could easily be dispensed with. The fourth: that thereby God's commandment be fulfilled, since He wills that we contemplate the stars and learn their motion; for whoever, being able, fails to do this ought to reckon that saying of Isaiah 5:12 spoken against himself: "They do not regard the work of the Lord." The fifth: so that the Jew — whom Scripture nonetheless proclaims a man of exceptional wisdom, Deuteronomy 4:6 — being ignorant of this science, may not become a laughingstock to non-Jews when they question him about the foundation of intercalation (so necessary for the lawful celebration of the festivals), but may rather have something to answer.

These, then, are the contents of the preface. The work itself is divided into twelve שערים [she'arim, "gates"] or chapters; and each chapter, in turn, into סימנים [simanim, "sections"] or paragraphs.

Caput I. Chapter I

Chapter I contains the teaching about the four elements, about the nine orbs of heaven, and about other matters pertaining to this. It has 30 sections.

1. That below the orb of the moon there are four elements, one of which is higher than another; and the first is explained.

2. The second element, that of water; joined with which, earth makes a single land-and-water globe [terraqueous globe].

3. That one is not to inquire into the cause of how the globe of the earth, suspended in the midst of the air, rests upon no base.

4. The third element, air; and concerning its three regions — lowest, middle, highest — and its qualities: cold, moist, hot, dry.

5. That air is divided into ten פנים [panim, "aspects"] (modes), where at the same time [is treated] the difference between נפש [nefesh], רוח [ruach], and נשמה [neshamah].
6. The fourth element, fire; and in particular, how these elements cohere one with another.
7. That certain more recent philosophers deny that that higher fire is an element.
8. On the number of the planets, their names, order, and period of revolution.
9. That each of the planets is placed separately in the expanse of heaven, and why they are called stars "of going" [itionis] and "wandering" [erratic].
10. On the eighth orb, which is called [the orb] of the fixed stars, and on its motion.
11. That all seven planets, together with the fixed stars, are carried round from west to east by means of their orbs.
12. On the ninth orb, called the diurnal orb, whose motion is contrary to the remaining eight orbs.
13. How can two contrary motions be conceived in one body?
14. How can it be conceived that one body (such as the prime mobile, i.e., the diurnal orb) drives round the remaining eight bodies (i.e., orbs), one within another?
15. It is explained how these two paradoxes, adduced in §§ 13 and 14, can stand together.
16. Continuation of the preceding.
17. Why that ninth orb is called the diurnal orb, and that it has but a single motion.
18. The various opinions of various [authors] concerning that ninth orb.
19. Some explanation of the figure inserted in the preceding § 18, exhibiting the four elements together with the nine orbs.

20. That the spheres of these orbs are like the skins of onions, between which there is nothing empty, and that they are as pure and translucent as sapphire, and do not intercept light.

21. On the axis, and on the poles of the sphere, or its pivots [cardines].

22. That those two poles or pivots — the one northern, the other southern — exist only in the ninth sphere.

23. That even those who deny that ninth orb must nonetheless concede a diurnal orb, that is, a supreme motion.

24. That each individual star moves daily around one of the poles, and completes that circular motion.

25. Whether the star stands motionless while the sphere revolves; or, on the contrary, the reverse?

26. How the arctic pole is to be found.

27. The figures of the Great Bear and the Little Bear [Ursa Major and Ursa Minor]; likewise, in what sense a pole is attributed to the eighth sphere, though properly it exists only in the ninth.

28. Demonstrations that the figure of the heaven is spherical [orbicular], not oval, etc.

29. That the spherical figure holds more than all the rest.

30. That the orb of the fixed stars is divided into 360 degrees, both in longitude and in latitude.

Cap. II. Chapter II

Chapter II. On the globe, on the number of its circles, on the elevation of the pole, and on what pertains to this. It has 24 sections, namely from no. 31 to 54.

31. On the nature of the globe, and on its diameter and poles.

32.

33. On the number of the circles of the globe, and their figure. 34–43. On the Equator. On the Horizon. On the Meridian. On the Zodiac. On the colures of the solstices and equinoxes. On the tropic of Cancer and of Capricorn, on the arctic polar [circle], on the antarctic.

33. On the distance of the equator, the tropic of Cancer, and the arctic polar circle from one another.
34. The method of finding the meridian.
35. To make an arc for measuring the longitude of the stars.
36. That the horizon and the meridian are the same for two men equally distant.
37. That by however much one moves away from the equator, by that much the pole either rises above or is depressed below his horizon.
38. That the stars around the arctic pole never set for us.
39. To find the four Tekufot [tekufot], i.e., the two solstices and the two equinoxes.
40. On the Quadrant.
41. To find the altitude of the sun and of the other stars.
42. To find the elevation of the arctic pole.
43. To find the moment of midnight for every day throughout the whole year.

Caput III. On the shape of the Earth, its dimension, its parts, and so on. It has 37 sections, from 55 to 91.

55. That the Earth is round.
56. That some people have sailed all the way around the terraqueous globe and returned to the very place they had set out from.
57. That the Earth stands at the center of the sphere of the stars, like a point at the center of a circle.
58. On the smallness of the Earth's globe when compared with the sphere of the stars.
59. That from the measure of the lines of the celestial globe one must gauge the measure of the lines of the terrestrial globe.

60. That the terrestrial globe too is divided into 360 degrees, both in latitude and in longitude; and the question of the point from which the numbering begins — namely, the prime meridian.

61. On what grounds the ancients established that the measure of the line of longitude — as regards half of it, that is — amounts to 180 degrees.

62. How many miles on the terrestrial globe are assigned to a single degree out of those 360 on the celestial globe.

63. The measure of the line encircling the Earth, that is, of the equator, and how many days someone would need to travel around it.

64. On the opinion of the ancients that half the terrestrial globe is submerged under water.

65. Whether the Earth rests upon the waters, or the waters upon the Earth.

66. On the opinion of the ancients that the torrid and the frigid zones are uninhabited; likewise, on the seven climes.

67. Why the ancients divided the globe of the Earth into seven climes.

68. A description of the figure of the globe — both as to the seas and as to the continent — together with its 8 parts.

69, 70. On two maps that display the form of the world.

71. The ancients' division of the world into three parts: Africa, Asia, and Europe.

72. That the sons of Noah divided these three parts among themselves.

73. On the discovery of the New World, America, in the year of the world 5252 [= 1492 CE].

74, 75. The fifth part of the world, Peru.

76. On the opinion of some that Peru is Solomon's Ophir.

77. The sixth part of the world, Guinea.

78. The seventh part of the world, namely the northern provinces.

79. The eighth part of the world, namely the southern globe, larger than each of the remaining parts individually.

80. How the places of the world and the bounds of the sea became known to men.

81. How the longitude and latitude of a land could become known to them — the answer being, among other things, by means of eclipses.

82. How this could be done even without considering eclipses.

83. How the longitude of islands is found, and so on.

84. How the longitude of provinces can be ascertained by means of the moon's motion.

85. The bounds of the four winds of the world: where they begin and where they end.

86. That the ancients distributed the horizon among 12 winds.

87. The moderns, among 32.

88. A table of the longitude and latitude of the principal places, and of certain islands as well, arranged in alphabetical order.

89. On what the Rabbis said, that Jerusalem is situated at the center of the world.

90. That the same authorities held that the land of Israel occupies a place loftier than all other lands.

91. Why the moderns changed the prime meridian that had been accepted from the ancients.

Caput IV. On the determination of times — of the year, the month, the week, the hours, and what pertains here. It has 15 sections, from 92 to 106.

92. On the five divisions of time in general — namely year, month, week, day, hour — and in particular on the year and the month.

93. That the sun does not, properly speaking, make the months, nor the moon the years.

94. On the natural day.

95. On the hours, and why they were devised.

96. Why they divided the day into 24 hours, neither more nor fewer.

97. The rationale for the seven days of the week.

98. On the dominion of the seven planets, each of which presides over its own hour

throughout the days of the whole week; and this is also why these days got their names.

99. That each planet presides not only over the first hour of the day to which it gives its name, but over the whole day.

100. On the equal hours of the natural day.

101. On the seasonal hours [horae temporales], namely 12 of the day and 12 of the night.

102. On what basis their number rests.

103. That the computation of intercalation, of the solstices and equinoxes, and of the new moons rests on these seasonal hours.

104. On the cause of night and on the shadow of the Earth.

105. Explanation of the word יום [yom, "day"], that is, of the day; and the distinction between the natural day and the day for doing work, and from what point it begins.

106. That the measurement of the natural day is grounded in the revolution of the daily sphere, that is, of the primum mobile.

Caput V. On the signs of the Zodiac and what pertains here. It has 25 sections, from 107 to 132.

107. On the Zodiac and the ecliptic — why they are so named — and on its breadth.

108. Why the ancients assigned that breadth to this circle.

109. Why the ancients made Aries the beginning of the signs of the Zodiac.

110. On the twofold motion of the zodiacal signs.

111. That the figures of the zodiacal signs are not equal to one another in dimension, either in longitude or in latitude.

112. That all the remaining heavenly bodies are distributed among these 12 zodiacal signs, in such a way that each of them contains 30 degrees of longitude and 180 of latitude; and that the remaining stars contained within this span are reckoned to that particular zodiacal sign.

113. That these 12 zodiacal signs can be considered in seven ways.

114. That, of the six zodiacal signs above the horizon, three are not eastern and three western — except only for those who dwell under the equator.

115. That each of the zodiacal signs, in its rising and ascent above the horizon, requires two hours before it has fully ascended.

116. That on each day, just as on each night, six zodiacal signs ascend above the horizon.

117. The reason why it comes about that the zodiacal signs rise for some inhabitants of the globe within a shorter, for others within a longer, span of time.

118. That in four places the degrees of the zodiacal signs coincide with the degrees of the equator.

119. In what order these zodiacal signs succeed one another through the four quadrants of the ecliptic.

120. A table showing the degrees and hours of the right and oblique ascension of the zodiacal signs.

121. A table of their ascension and descension on the Prague horizon.

122. That some inhabitants of the globe (the Icelanders, and so on) have the Zodiac above the horizon the whole day, and so on.

123. The account of the zodiacal signs with respect to inhabitants under the arctic polar circle.

124. That for some, three zodiacal signs never set (namely for those dwelling under the 70th degree) and three others never rise, while the remaining six both set and rise for them.

125. That for some, four are always above the horizon and four below it; but for others, six below the same horizon and as many above it.

126. On their rising, whether at dawn — that is, cosmical — or in the evening — that is, acronychal.

127. At what time of year each of them rises.

128. That their rising is not precisely the same throughout the whole year, nor the same for all inhabitants of the globe.

129. On the time of the revolution of the Zodiac.

130. That after many years have elapsed, the whole disposition of the stars will be changed.

Caput VI. On the declinations of the sun from the equator, and on the resulting length or shortness of the days, and so on. It has 31 sections, from 132 to 162.

132. On the declination of the sun, and on the 182 revolutions (and the fraction beyond) that it completes over half a year from one tropic to the other.

133. Many of the sun's circuits are linked together — for example, through Aries and Libra, through Gemini and Leo, and so on.

134. The sun's circuits do not complete perfect circles, but on returning reach only the nearest degree.

135.

136. Continuation.

136. An illustration of the inequality of days and nights, by way of comparison.

137. Those living beneath the equator have days and nights of equal length.

138. At the time of the two Tekufot (the equinoctial ones), the days and nights are equal for very many other peoples as well.

139. The day at the spring equinox is longer than at the autumn equinox.

140. The natural days are not equal even beneath the equator — except that the inequality is not perceptible there.

141. a) The reason for the inequality of days in our northern provinces.

142. b) The length of the days of Teves, i.e. December, is not in every respect equal to the length of the nights of Tammuz, i.e. June, nor are the days of Tammuz equal to the nights of Teves.

143. For some, the length of the day is 24 hours.

144. For some, the day lasts one or two months, or longer; and likewise the night.

145. For some, the day lasts 4 months, and so too the night.

146. For those living beneath the arctic pole, the day lasts six months, and so on.

147. How to find on the globe the length or shortness of the day, for all places and at all seasons of the year.

148. On the different beginnings of the day, and the different moments of noon, according to the different inhabitants of the world.

149. For some beneath the equator daylight comes sooner, for others later.

150. For those living at the same degree of latitude, the day is of equal length.

151. Those at the same degree of longitude do indeed have the same noon simultaneously, but not the same beginning of day and night — except at the time of the equinox, in the months of Nisan and Tishri.

152. For those who live neither at the same longitude nor at the same latitude, what is the reckoning of the day? [The item number reads "quaeam"; recte *quaenam*.]

153. In many western provinces the sun rises earlier than in the eastern ones.

Caput VII. De Cursu solis, dimensione anni etc.

[Chapter VII. On the Course of the Sun, the Measurement of the Year, etc. It has 25 sections, from 163 to 187.]

154.

155. Among the sages of the Jews it was agreed that, when they mean to specify the time of particular actions or particular events, they say it happened at this or that hour before or after midnight, before or after noon; and the reason why.

155. On summer and winter, and that for those living beneath the equator there are two summers in the year and two winters.

156. For neighboring inhabitants too, between the equator and the two tropics, these same four changes of two summers and two winters occur — but with some difference.

157. The character of the sun, of summer, and of winter, beneath the Tropic of Cancer and beyond.

158. Why it grows hotter at noon than in the evening, and hotter in the evening than in the morning? And why it is colder in winter than in summer?

159. Day and night, summer and winter, and the rest of the seasons depend on the sun's twofold motion: the voluntary (from west to east) and the necessary (from east to west).

160. At what place on earth does each day of the week begin to be called by its name, and at what place does it end? (The author calls it a difficult question, one that has exercised many most learned Rabbis.)

161. Whoever circles the globe from east to west loses one day of the week, and whoever goes from west to east gains one day.

162. In the sun, as in the other six planets, various changes are found.

163. Definition of the solar year, and by how great a span of time it is measured.

164. How much space the sun completes within the ecliptic on each day of the year (by its motion toward one or other of the tropics)?

165. How the time of the year is to be computed?

166.

168. On the sun's twofold revolution, internal and external; a third is added.

167.

170. A figure representing the matter.

168. The sun never runs out beyond its own sphere.

169.

173.

174. On the five circles of the sun.

170. In what sense the Rabbis in Bereishis Rabbah [*Genesis Rabbah*] say that the sun and moon are found in the second firmament.

Caput VIII. De luna, eius motu, et aliis huc pertinentibus

[Chapter VIII. On the Moon, its Motion, and other things pertaining hereto. It has 32 sections, from 188 to 219.]

178. The sun now recedes farther from the earth, now draws nearer.

179. There are four motions of the sun.

180. On the sun's twofold path — one called אמצעי [Hebrew: *amtza'i*, "mean"] *media*, the other אמתי [Hebrew: *amiti*, "true"] *vera* — and on the difference between the two.

181. The mean place sometimes runs ahead of the true, and is sometimes behind it.

182. The sun completes its direct path in two different times, and in two equal times [it completes] two different paths.

183. The Tekufot — that is, the solstices and equinoxes — are not exactly equal.

184. And hence too the lengths of the natural days are unequal.

185. The difference of time between the true and the mean Tekufah.

186. On the sphere of the moon.

187.

190. On the deviations of the moon.

188. On the motions of the head of the Dragon and of its tail.

189. The place of the moon is computed according to longitude and latitude.

190. How great is the number of degrees of the moon's deviation.

191.

195.

196. On the theory of the epicycles, both of the moon and of the other five planets, and their figure.

192. On the spheres of the moon and of the other planets.

193. On the moon's variation, between the mean place and the true.

194. The difference between the true and the mean new moon.

195. The moon's changes as depending on the epicycle.

196. The six motions of the moon's spheres.

197. The reckonings of the Tekufot and new moons are grounded by the Rabbis on the mean path.

198.

204. On the time of the moon's revolution through its own sphere; likewise on the time of its epicycle; and on the time of the measure of the new moon; and on the difference of time between the two.

199. On the moon's opposing motions, מתון [Hebrew: *matun*, "slow"] slow and נחוץ [Hebrew: *nachutz*, "swift"] swift.

200.

207. On the many and various revolutions of the moon.

201. On parallax [parallaxis], that is, on the difference between the line going out from the center of the earth and the line going out from the eye of the observer.

202.

210.

211. On new moons, and on the various changes, or phases, of the moon throughout the whole month; and on its waxing

and waning, and how many hours of the night it moves above the horizon.

203. How long the moon lies hidden in each month, namely 24 hours before the new moon and as many after it.

Caput IX. De eclipsibus solis et lunae, et quae huc spectant

[Chapter IX. On Eclipses of the Sun and Moon, and what pertains hereto. It has 12 sections, from 220 to 231.]

213. On the time of the moon's motion in each month, in which it is completed — which is 29 days, 12 hours, 793 minutes; whence is this established for the Jews?

214. From what place on earth the starting point for computing new moons and Tekufot is to be sought.

215. No star completes its own revolution within the time of the revolution of the primum mobile [primum mobile].

216. To observe the voluntary motion of all seven planets.

217. There are those who deny the moon's retrograde motion and its epicycles, against Ptolemy.

218. What is the moon's greatest distance from the earth's globe, etc. — that is, on apogee and perigee.

219. On the darkening and eclipse of the moon.

220. On the character of the earth's shadow in relation to the lunar eclipse.

221. A figure of the circle of the moon's declination; likewise, that all eclipses occur either in the head or in the tail of the Dragon.

222. Why lunar eclipses do not occur in every month.

223. Why the moon's darkening is sometimes detected only at its edge, and when it fully emerges from that shadow.

224. Astronomers divided the times of the darkening into five parts.

225. On the darkening of the sun, and on the vast difference between its darkening and the moon's.

226. The cause of a solar eclipse is the interposition of the moon, which obstructs the sun's rays.

227. How the moon, six thousand times smaller than the sun, can block the view of a body far larger than itself?

228. Why the darkening of the sun does not occur in every month?

229. Why the sun's eclipse is seen as total in one place, partial in another, and not at all elsewhere.

230. How much time passes between one eclipse and another, and how many darkenings are possible in a single year.

Caput X. De circumuolutionibus reliquorum quinque planetarum, et quid circa illas tenendum sit

[Chapter X. On the Revolutions of the remaining Five Planets, and what is to be held concerning them. It has 10 sections, from 232 to 241.]

232. The planets are sometimes direct, retrograde, and stationary.

233. Why does some one of the planets seem to stand still and not move from its place?

234. They all lie hidden beneath the sun's rays, and how they come forth from them.

235. That the bright planet — that is, Venus — sometimes precedes the sun, sometimes follows it, and now and then is not seen at all; and that it is then called now the morning star, now the evening star.

236. That Mercury too keeps to the motion of Venus.

237. If the three superior planets — Saturn, Jupiter, Mars — rise, how do they come to lie beneath the rays of the sun?

238. Whether the planets have their own light or one borrowed from the sun?

239. How large the body of each of the planets is, compared with the globe of the earth?

240. Within what span of time each of the 7 planets completes its second motion, from the south toward the north?

241. On the maximum declination of the planets.

Chapter IX [recte: XI]. On the Quadrant, and to what end it is customarily used

Namely, for measuring and finding, in all places, the altitude of the pole, of the sun, and of all the other stars — how far they stand from the horizon; likewise the place of the sun in the zodiac on every day of the year, the time of the sun's rising and setting, the length of days and nights in all places and on every day throughout the year, and other matters pertaining to this.

Since it is not possible, given the constraints of time and other things, to pursue all of this, it will be enough to extract a few points. The chapter contains 46 sections, from 242 to 288.

242–247. On the quadrant, for measuring the altitude of the axis and of the stars.

248, 249. To find, by means of the quadrant, the altitude of the sun and of the stars.

250, 251. To find, at any time and in any place, the altitude of the arctic pole.

Chapter XII. It contains an appendix on comets and other matters that the author found it useful to append

Containing 17 sections, from 289 to 305.

289. On tailed stars, or comets.

290. What region in the expanse of the heavens comets occupy.

291. Where comets come from and where they go, how they arise, why they appear so suddenly and gradually cease; and also, incidentally, on the nature of thunder and lightning.

292. On the revolution and motion of comets.

293. How long a comet usually remains visible.

294. What place in the ecliptic comets usually occupy?

295. That comets and other celestial portents exist over many years — indeed every year — even though they do not appear.

296. Whether an astronomer can foresee the appearance of comets?

297. Whether solar and lunar eclipses portend evil?

298. Whether the visions and predictions of astronomers about calamities always correspond to the outcome, or are sometimes empty?

299. On the 28 מחנות לבנה [Hebrew: maḥanot levanah, "stations (encampments) of the moon"] — that is, the mansions of the moon (to each of which 13 degrees in the ecliptic are assigned) — and what effect they have?

300. On the aspects: opposition, trine, square, sextile.

301. On their use.

302. On the special usefulness of the square [aspect].

303. Under the dominion of which zodiacal sign each nation and kingdom of Europe falls? (From the hypothesis of the Jews that God assigned certain nations to be governed by individual stars, from Deuteronomy IV, 19.)

304. Whether the people of Israel too is subject to the dominion of the stars? There are those who affirm it; there are those who deny it.

305. The number of the stars, of which 21 are northern and 15 southern; and how many stars each constellation contains within itself?

At last the author brings his work to a close by recalling the outstanding services of the Emperor Rudolph [Rudolph II] to the science of astronomy. For in the year of the world 5360, the year of Christ 1600, Rudolph summoned Tycho Brahe from Denmark to himself at Prague, at an annual salary of 3000 Joachimsthalers [Ioachimici], and had 13 chambers fitted out in a single row for him, together with 12 other most learned men — in each of these stood an instrument [tubus, "sighting-tube"] of exceptional workmanship and value. By their aid the settings of the heavenly bodies were observed with the utmost diligence. The author says that he himself took part in their company three times, each time for five days and with all his energy, and profited greatly from their teaching. And finally he adds Tycho's hypothesis [the Tychonic system].

From all this it is clear that this labor of Gans will prove neither an unpleasant nor a useless read for those skilled in the Hebrew language. For it is, as the editor truly declared on the title page, lucidly written. And it can be established from this that even the more recent age has brought forth, among the Jews, men of no contemptible learning. Meanwhile there seems to be no need for any lengthy commendation of the book, since it is abundantly clear from the section headings how diligently the author was versed in this subject. Yet in the end, praise is deservedly due to the zeal for serving Hebrew letters that Ber Hess [Ber Hess of Halberstadt] — a man held in esteem among his own people — has shown to the learned, Jews and Christians alike, by generously expending the funds for the publishing of this work; by whose care it has come about that this book, after a century and more, has now come forth into the light out of its obscurity; and at whose request I have gladly excerpted these things — by way of an overview, as it were [Greek: ἀνάβλεψις (anablepsis, "a looking-over, review") [?]] — so that what the book contains might be made plain.