A PARIS ASTRONOMER OF 1290

Fritz S. Pedersen

1. The treatise "Sicut dicit Hermes in libro De natura dierum(!), Homo est nexus dei et mundi" (Thorndike & Kibre 1963 col.1484) is a literal commentary on a version of the well-known *canones Azarchelis* on the Tables for Toledo, "Quoniam cuiusque" (T.& K. 1268; Carmody 1956, no.31,1a: "Can.Az." or "canons" in the following). I only know this commentary from the manuscript in Florence mentioned below, and have not seen any further references to it. I believe it to have been composed A.D.1290 in Paris, and probably for university teaching, though it does not say so. I also think that it constituted the main source of John of Sicily's slightly younger and more wide-spread commentary (Duhem 4,6-10; Poulle, DSB), an edition of which will appear shortly. Since the present text may be longer in the coming, I take the opportunity to present enough details from it to make it recognizable in other manuscripts. I hope that anyone who has further information will care to tell me of it, c/o IGLM (Njalsgade 90, DK-2300 Cph. S).

The text is referred to by folios in the manuscript, supplemented by paragraph numbers from my transcript, for future use. "Sample A" means §16 below, section A. For John of Sicily, folios of Par.lat.7266 (P) are referred to; on occasion, reference is also made to the *Scripta Marsiliensis super canones Azarchelis* (Erfurt CA 2°394, printed in part by Curtze 1900, 349-53), which I believe to be a collection of excerpts from John (cf.§15 and note to Sample F).

2. Manuscript: Firenze, Bibl. Medicea Laurenziana, Ashb.211. Vellum, cm. 22½ × 15½, ff.IV+306, 13th-14th century. Several hands, Italian of 14th century unless otherwise noted; insertions, however, mostly 15th century. Microfilm provided by library.

Ir-IIr (blank except for shelf-mark & stamp) IIv (index, 18th c.:) Anonymus. Tabulae Astronomicae /inter quas nonnullae Alphonsi Regis\ / -- Commentarii in quaedam verba Hermetis De natura dierum, et quaedam alia Astronomica et Astrologica. / Azzachel......... Varia Opuscula Astronomica, Astrologica, Chronologica. / (another coeval hand:) ?Sęc.XV (corr. to "XIII", modern) Codex ms. membranaceus. IIIr-v (blank except for "211") IVr (rules for houses, etc., mentioning Cecco d'Ascoli:) Astrolabii notitia iudiciorum astrologiae... IVv Nota quod introductoriorum astrologiae quaedam procedunt narrative...(:½ page mentioning Alcabitius, Ptolemy's Centiloq. and Quadrip., Albumasar, mag. Thadeus; in other hands, on a writing by Gerardus de Brolio on Aristotle's books on animals, reported to be owned by one mag. Jacobus Baronis, surgeon of Bologna; and on an Albumasar owned by the same).

1r (top, hand uncertain, upper line almost cut away:) <--> Azzachelis. 1ra-62vb (writing 13th-14th c., possibly French:) Inter cetera veritatis... divides zodiacum per (custode:) numerum annorum. (:John of Sicily, Expos. super canones Azarchelis, broken off in section on mean motion tables, P 178vb; the sequel is "num.ann. totius revolutionis et numerus quotiens".)

63ra-160vb (our text; hand of 13th-14th c., still possibly French:) Sicut dicit Hermes in libro De natura dierum(!), "Homo est nexus dei et mundi, supra mundum et subnexus deo". Haec propositio quantum ad omnia 3 membra declarari potest; et primo quantum ad membrum primum, quo dicitur quod homo est nexus dei et mundi. Quaecumque enim distantia si connecti habeant...(ends in mid-column:) "Et si kardagas declinationis": in hoc capitulo docet auctor invenire <-->

161ra-173ra (Canones Azarchelis:) Incipiunt canones in motibus caelestium corporum «azzachelis». Quoniam cuiusque...usque in perfectionem 60 graduum. (Paragraph numbering in margin, 15th c., corresponding to one on 63r ff. I ignore this numbering.)

173v-175r (faint, possibly a legal document) 175v-176v (astrological diagrams, and notes and recipes in Latin and Italian. Italian cursives of 14th-15th c.)

177r-180v (Theorica planetarum Gerardi:) Circulus excentricus...bicubitum vel tricubitum. 180v-181r (addition on eclipses, not in T&K:) Quantitas solis dicitur quantitas... 181v-184v (theory of sun, moon, and eclipses, not in T&K:) Sol dicitur habere suum excentricum... 184v-185r (on planets and tides, Italian cursive, 14th-15th c.) 185v (rota, "calitatis signorum")

186r-306r (several series of tables, among which: 186r-195v, mean motion tables for Toulouse, etc.; a list of radices for Paris, and one headed 1320. Hand probably Italian. Notes of 15th c. in Italian cursive. - 196r-264v, Toledan tables in various hands, mostly one of 13th-14th c., with notes and supplements in Italian hands, and 15th c. notes written in Spanish. - 265r-301r, various tables in Italian hands, 14th-15th c.) 306v (½ column, not in T&K:) Animodar id est investigatio...

3. Summary of text. Recording a selection of numbers which recur in several contexts, and those of the larger notes which digress from the current subject-matter. The chapter-division here given is just for convenience; it also recapitulates the order of paragraphs in the canons, a list of which can be found in Millás 1943/50 p.37-42. The canons are cited by paragraphs from an uncritical text which I hope to print for reference within a year's time.

63ra-64ra (§1-10) Preamble, *incipit* "Sicut dicit Hermes" (§2 above).

Authorities cited: for man's place in world, Hermes, Aristotle (Ethics 3), Algazel, Alpharabius; for division of sciences, Aristotle (De An. 3); for astronomy, Moses, Abrachis, Ptolemy (Almagest), Albumasar, Albategni, Azarchel.

CHRONOLOGY:

64ra-73ra (§11-68) Conversion of dates, *inc.* "Unde quia tempus comparatur ad motum sicut mensura ad mensurabile".

The common example is *A.D.1291, July 10th*, noon, expressed as: Christian era, $1290^{y}+6^{m}+10^{d}$ elapsed; Arab era, $689^{y}+6^{m}+12^{d}$, or 244348^{d}, elapsed; also in Iezdegerd and Seleucid eras. -Note on sexagesimal number-notation in tables (67ra-b,§41).

TRIGONOMETRY OF EIGHTH SPHERE:

73ra-78rb (§69-107) Finding sines and solar declinations from arcs, and vice versa, *inc.* "Cum cuiuslibet gradus etc. (:Can.Az.52): superius usque nunc determinavit".

Notes on proportional reckoning, and on calculation with fractional numbers, mainly for use in linear interpolation (74vb,§80; 76va,§94). The declination table of Almeon is recommended (§8 below).

78va-80va (§108-118) Finding geographical latitude from solar or stellar observations, *inc.* "Cum latitudinem cuiusque regionis (:Can.Az.67): cum auctor iam determinavit de modo inveniendi declinationem". - A round value of 48° for the latitude of *Paris* occurs repeatedly.

80va-90ra (§119-171) Finding right and oblique ascensions from arcs on ecliptic, and vice versa, *inc.* "Cum elevationes signorum in circulo directo (:Can.Az.72): postquam auctor docuit per declinationem".

Tabular values for oblique ascensions, when used, are those for the 7th climate, but the individual latitude employed is 48°13', said to be for *Paris* (Sample A). - Notes on: the shadow function as used for computing oblique ascensions at any latitude (84vb-85vb,§143-8); on subtraction of arcs modulo 360° (88va-b,§165); and on the defects of interpolation (Sample B).

90ra-99ra (§172-223) Finding: day-arc and day-length from solar longitude; hour-of-day from observed solar altitude, and vice versa; ascendent from hour-of-day and vice versa; houses. *Inc.* "Cum portionem circuli directi (:Can.Az.98): docet inventionem ascensionum".

Some values repeated in the examples: *(a)* Summer solstice; day-arc for 7th climate, 238°56'; arc of 1 seasonal hour, 19°54'(40"); day-length 15^h56^m; meridian solar altitude, for *Paris*, ca.64°; observed altitude, 50°; hour after sunrise, ca. 4^h3^m seasonal; ascendent, Vir 1°10', or Vir 1°42' on a less reliable method. *(b)* Night following: arc of 1 hour of night, 10° 15'(20") [not 10°5']; hour after sunset, $3^h(4^m)$ seasonal; ascendent, Aqu 4°49'; 10th house, Sag 2°20'. *(c)* Equinox; meridian altitude for *Paris*, 41°47'; observed altitude, 30°; hour after sunrise, 3^h15^m seasonal. - Note on division of numbers by 12 (91va;§184).

99ra-100va (§224-32) Finding shadow function from solar altitude (30°), and vice versa, *inc.* "Si autem umbram per solis altitudinem (:Can.Az.122): postquam iam docuit per horas invenire".

Directions for finding squares and square-roots of numbers with fractions, with a dating to *A.D.1289 Aug.5* (Sample C).

PLANETARY MOTIONS:

100va-112ra (§233-97) Ecliptical longitudes of sun, moon, node, and superior planets, with ample explanations on planetary theory in each case, covering, but not identical with, the Theorica Planetarum Gerardi. The inferior planets are treated perfunctorily. *Inc.* "Post motuum superioris cir-

culi (:Can.Az.127): postquam superius determinatum est de sinibus et declinationibus et de aliis sphaerae octavae".

All the examples are for the Arab date 688^y+ 8 months elapsed, or *A.D.1290, Sep.5* at noon, and are reduced to the meridian of *Paris* (11°30', or 46^m, East of Toledo: 104rb,§257). The motion of the eighth sphere is set at 9°22'20" here and elsewhere, computed for *A.D.1290* running, or A.H.689 running (106rb,§266, cf.149va,§505). This should be added to the true longitudes obtained, which are:

Sun: 5^s 9°39'43" (106rb,§266), or within Vir 20° of ninth sphere;
Moon: 5^s11°25'38" (108ra,§274), for Toledo, by mistake;
Node: 5^s 3°10'28" (108vb,§277)
Mars: 8^s 9°56' 1" (111rb,§289).

The time chosen is within a few hours of the solar eclipse calculated later on. - Notes on: lunar years, for entering tables (101va-b,§240); conversion between different meridians (102ra,§241; 104rb-va,§257-8); machine to show the motion of Mercury (Sample D).

112rb-115rb (§298-320) Stations, retrogradations; solar declination, planetary latitudes. *Inc.* "Cum autem etc. (:Can.Az.152): postquam auctor docuit invenire loca planetarum omnium".

The examples use elements from the longitude calculations above, and are thus valid for the same date and place. The stations are visualized as the points of contact with the epicycle of its tangents from the earth, as in the Theorica Planetarum.

115rb-145vb (§321-481) Solar and lunar eclipses, *inc.* "Cum autem volueris invenire (:Can.Az.167): determinat de quadam passione solis et lunae". With extensive explanations and one example for each kind of eclipse.

When sought during A.H.689 running, they are found as follows, for *Paris*, equation of time taken into account. *Solar*: mid-eclipse at 688^y+7^m+29^d, or *A.D.1290 Sep.5*, 19^h55^m after noon of our Sep.4 (139va,§446). 9;51 digits eclipsed (140ra,§448). Beginning of eclipse, 18^h50^m p.m. (145va-b,§480). *Lunar*: mid-eclipse at 688^y+7^m+14^d, or *A.D.1290 Aug.22* ("21",text), 15^h38^m after noon of our Aug.21 (143vb,§470). 4;52 digits eclipsed (143vb,§472). Beginning of eclipse, 14^h14^m p.m. (145vb,§481). The eclipses correspond to Oppolzer no. 5957 and 3867, both in fact visible in Paris. - Notes on: equation of time, where the sun is simplistically assumed to run evenly in the ecliptic (120ra-121va,§347-52); criticism of canon on parallax table (Sample F); multiplication by certain numbers with fractions, to find diameters of luminaries and earth's shadow (134ra-b,va-b,135va-b:§§420,422, 427); magnitudes of total eclipses, annular solar eclipses (136vb-137ra, §432-3).

145vb-146vb (§482-4) Tables of fixed stars and of geographical coordinates, *inc.* "Si autem in quo gradu (:Can.Az.209): postquam auctor determinavit de hac passione quae est eclipsis".

The examples are for Aldebaran (used at 151va+, cf. to Sample H), and for the longitudes of *Paris* (40° from W) and Toledo (28½° from W), thus with the usual time difference of 46^m.

146vb-149rb (§485-503) Aspects and projections of rays; risings and settings of planets; visibility periods. *Inc.* "Cum autem proiectiones radio-

rum (:Can.Az.211): auctor hic intendens determinare". A repeated example is for Saturn in Psc 15°, not seen elsewhere.

149rb-150ra (§504-6) Motion of eighth sphere, *inc.* "Cum motum accessionis et recessionis (:Can.Az.221): postquam auctor iam docuit aequare vel invenire vera loca stellarum".

The value is found to be 9°22'22" for A.H.689 running, or about *A.D.1290* running, and is essentially the one used throughout the text. Our author is brief and does not mention any theory but Thebit's.

150ra (§507) Remark on "centrum" of planet (Can.Az.223).

150ra-151va (§508-17) Angular velocity, "buth", of sun; time of sun's entrance into a given point (vernal equinox used); remarks on "revolutio anni natalis/mundani". *Inc.* "Cum autem buth solis (:Can.Az.224): hic intendit artem inveniendi horas noctis per stellas".

The text departs from the date *A.D.1290*, 5^h34^m after noon of *Sep.4* (thus "Sep.5"). This is the time of mean conjunction which was used in §438 as a step in finding the solar eclipse. The next vernal equinox (Toledo, eighth sphere) will then occur A.D.1291 March 24 ("25"), 6^h44^m p.m., according to mean motion; with true motion the time is March 23 ("10 Kal.Apr."), 7^h33^m p.m. ($1\frac{1}{2}^h$ after sunset, text). The author does not carry through the reduction for the motion of the eighth sphere.

151ra-154vb (§519-35) Finding: day-arc of star; hour-of-night from observed stellar altitude; ascendent from hour-of-night. *Inc.* "Cum cuiuslibet planetae (:Can.Az.230): postquam auctor dedit artem inveniendi horam qua planeta ingreditur quodvis minutum caeli". Rules much like those at 90ra+.

The example uses the latitude of 48°40' for the middle of the 7th climate, and Paris is not mentioned. Key values: Aldebaran, latitude 5°10'S, longitude Tau 28° (see to Sample H); day-arc, 214°50' or 14^h19^m; meridian altitude, ca.56°; observed altitude, 35°; hour after sunset, 6^h51^m seasonal, if the sun is in Vir 20° (this value also at 100va+); ascendent, Can 27°. - Notes: the tabular longitudes are now about *112 years* old and should be up-dated; correction of results by instrument (both in Sample H).

154vb-160vb Calculation of sines, mainly those at intervals of 15°, *inc.* "Quia in huius operis etc. (:Can.Az.236): quia auctor superius, determinando de sinibus et declinationibus, demonstrationem sinuum et declinationum omisit". Of this text, the part contained in 154vb-156vb (end of column) is found appended to John of Sicily's work in several manuscripts. For the attribution see §15 below.

Notes: directions for finding square-roots and squares of numbers with or without fractions, using linear interpolation (159ra-va,§598-9). The procedure for squares repeats that of Sample C, though not in wording; the square-root method improves upon the faulty one, ibid., cf. also §10 below. This section is unfinished in our manuscript, since the scribe left off just after having begun the chapter on declinations; but at least, not much text was left to be commented on.

4. Location etc.: The treatise was evidently meant for use in Paris, since this is the pervading instance of an individual place, and the only one the author has been at a liberty to choose (e.g. Sample A §139). Also mentioned are Toledo, Cremona, Arim, and Gades Herculis/Alexandri, as points of reference for the tables, or taken over from examples in the canons. The last part of the text (150ra+,§508+) is silent about Paris, using just the 7th climate (e.g. Sample H §522); I cannot say whether this indicates a change of source. In any case the latitude of $48^{o}13'$ for Paris happens to be Albattani's value for the 7th climate (Toomer 1968 p.109).

5. There are two proper datings in the text, one of them yielding a lower date at A.D.1289 Aug.5 (Sample C §230), the other one implying the year A.H. 689 or about A.D.1290 (Sample H §525 with note). Probably these years should be taken as running. - In the examples, one set of dates seems to be centered around the solar eclipse calculated for A.D.1290 running, Sep.5 (cf. 115rb+; 100va+, 150ra+). I suppose that the eclipse calculation is meant as a prediction, thus constituting an upper date for the eclipse section if not for the rest. The only other prevalent date, in the section on chronology, is the later one of A.D.1291 July 10: this may be simply arbitrary, or may indicate that this section was composed later. - Thus, significant parts of our text were probably composed during the first half of 1290, or within a few months to either side. It may also be fairly certain that the eclipse calculation was done at an early stage of the work, and that the other examples showing values coupled to it were composed or at least revised by our author himself.

6. At the risk of just repeating what can be said of any literal commentary, I shall briefly note some compository features of this one. It may be taken to consist of sections, each of which contains lemma, theme, division, paraphrase of canon, and numerical example, in this order, except that the division and/or the example may be left out, and paraphrase and example are often intermingled. Notes may occur everywhere except just before the theme. - Samples B and E below contain entire sections, on which the following may be to some extent verified.

A theme, with the typical word "docet", sometimes "determinat", "exsequitur", etc., occasionally has a recapitulation, thus, "Postquam auctor docuit...docet hic...". - The division may run "et facit duo, quia primo *theme1*, secundo *theme2*, ibi *lemma2*". *Theme1* pertains to the running section, whereas *lemma2* and *theme2* are left pending, to be resumed when a later section is to be introduced. Since the sections occur in the order of the ca-

nons, the last *lemma2* plus *theme2* currently pending will be the first to be resumed. Any such later section may of course contain a division of its own. Any division may have several layers like the one cited, subsequent ones often beginning "adhuc primo..." and dividing *theme1* of the preceding layer: thus the theme proper to the paraphrase following will be *theme1* of the last layer. In one way or the other, John of Sicily may reach 15 levels of division; I have not counted those of our text. – The paraphrase mostly begins with "et dicit auctor quod", "sententia capituli est", "sententia ...stat in hoc quod" or variants. The verb "exponatur" is rare; "quaedam exponantur" is used in the few cases where the paraphrase degenerates into scattered lemmas with their several explanations. When mixed with a numerical example, the paraphrase may begin "sententia capituli ponatur in exemplo", etc. The null paraphrase is "patet", which may occur inside a division. – Examples are typically introduced by "verbi gratia", "esto quod", "exemplum...sit istud", or combinations. Demonstrations on diagrams are here considered as notes, since they are rarely thus introduced except when mixed with numerical examples. – Notes are of varying contents, as instanced in §3 above. They may begin with "nota quod", "notandum/advertendum/intellegendum est quod", sometimes prefixed with "ad evidentiam/intellectum huius capituli" or similar. As mentioned, notes may stand almost anywhere in the text. When a note is used as reason for a subsequent layer in a division, its usual form is "et quia...ideo..."; and the common notes beginning "causa autem quare" of course tend to stand somewhere after the paraphrase. Apart from that, the form of notes does not seem to depend much on their position. Recurrent subjects are theory and definitions, early in a section, and the author's presuppositions, "supposita", without a fixed place. Among the weighty notes are those containing or consisting of demonstrations on diagrams, sometimes signalled by "ad quod ostendendum" or some variant of "demonstratio". Objections such as "contra diceres tu...dico quod..." occur (Sample G), but our author incorporates no entire questions.

7. Since obviously the notes constitute our author's most individual (even if scarcely original) contribution, a few of their conspicuous features will be presented in the next paragraphs, notably where the author speaks in the first person and/or states an opinion about the canons or tables. These features should not be taken as representative of the text.

8. Apart from the authorities cited in the Preface, no doubt at second hand, our text quotes pretty few different sources. A *Theorica planetarum* is presupposed for the section on planetary motions (101ra,§235); and a lot

of quotations, explicit or not, and never with an author's name, serve to confirm that as usual this is the so-called Theorica Planetarum Gerardi. Occasionally our text develops into (or reproduces?) a commentary on it, as in Sample D. - The common *kalendarium Linconiensis*, of Grosseteste, is used in date conversion. - *Ptolemy* is only mentioned in connexion with his value for the obliquity of the ecliptic ($23^{o}51'$, probably from the Toledo Tables or the canons); *Almeon* is used as a label for the value of 23^{o} $33'$, and for the table of solar declination found with the Toledo Tables, which is repeatedly recommended by our author (e.g.77va,§100), following the canons. - On the theory of the motion of the eighth sphere, the reader is referred to *Thebit* without much further comment (150ra,§506). - *Euclid* is cited three times for the theorem of Pythagoras, once for a congruence theorem.

9. Vaguer parallels may indicate various levels of information. A lot of simple statements are probably meant to make users recall the Sphere of *Sacrobosco*; he may also be the *quidam* with whom our author is at issue twice (102va-b,§247; 137rb,§434) concerning the relationship between the solar deferent and the ecliptic. On the whole the reader is supposed to be familiar with integer arithmetics, the common circles on the sphere, and basic computus, as given by the elementary parts of Sacrobosco's works with the aid of Grosseteste's calendar. Explanations are, however, once more offered for the more advanced parts of these subjects, such as for square-root extraction (Sample C §228, echoing Sacrobosco's Algorism), for right and oblique ascensions, and for other subjects shared with the canons. - The author used an *astrolabe* for computation, and perhaps expected the users to (§12 below). - Some patchy knowledge of *Euclid*, or extracts of him, turns up in the citations (§8 above) and in the terminology of the demonstrations (cf. Sample A §138, similar triangles).

There are other common authors and subjects which the author does not know or does not care to present. Had he known the geometric algebra of Euclid, he would hardly have bothered to take the extra square in Sample C §229. He had not read John of Seville's Algorism, or not the fractional parts of it, where he could have found a good solution for the task of Sample C §230. He had no use for proper spherical trigonometry such as offered e.g. by Albattani or the Lesser Almagest; his rectilinear demonstrations (e.g. Sample A §138) may descend from a tract on the sector figure, but I have not seen a contemporary source. On the whole, our text shows no striking resemblance to most of the works from which John of Sicily was to sup-

plement it, such as Albattani, Alfargani or Campanus; there may be echos of the Lesser Almagest (Sample E) and of William of England's Astrologia, whether directly or not. The spherical models for the planets, ultimately from Ptolemy's Planetary Hypotheses and current in the time, were incorporated by John (cf. Duhem 4, p.7-8). Such models are once alluded to as if known ("licet omnes orbes sint pervii luminis et diaphani...", 102va,§247), but apparently they were considered to be outside the scope of the treatment.

Among works and subjects on the same general level as this text, only the Theorica Planetarum is well attested as known to the author and users. One may even wonder how well the users were expected to know it, since most of the subject-matter is here again fully treated with a view to calculations. Much space is also given to fractional arithmetics, mainly sexagesimal calculation, and to the workings of arithmetical proportions, with many examples. This is mostly occasioned by the ubiquitous need for interpolation in the tables and elsewhere (Sample B), a procedure also used for other purposes, more or less aptly (Sample C, cf. above and §10), and thus apparently a standard tool supplanting much of the doctrine of the works on fractional arithmetics, none of which is ever cited. - In short our treatment is theoretically traditional but seems to bear witness to a self-contained practice of calculation. On a flight of fancy, if Peter of Dacia's expression "apud aequantes" (§14 below) refers to a real group of persons, our author would belong to them. He just calls himself a "plain astronomer",§13.

10. The text shows no consistent intention to <u>criticize</u> the canons and tables, but it does discuss them on various occasions. Numbers may be deliberately checked for one purpose or the other: thus the author uses the solar equation tables for verifying that the mean conjunction tables contain the longitudes they purport to (117rb,va-b,§331-2), and finds only a slight discrepancy. He sometimes uses instruments to check his calculations (§12 below), in one case revealing a corruption in his text of the canons (Sample H). Where he advises the reader of how to verify theory or calculation by alternative means (e.g. Sample F, §379 end), of course he may or may not have done so for himself. - More often comments are evoked by accidental confrontation between results, notably in Sample B, where a comparison of the result with the tabular value leads our author to discuss the applicability of interpolation, and later on to dissuade the reader from using several similar canons. The faulty square-root extraction of Sample C §230, used once later (155rb), disappears as soon as the results might have been compared to the sine tables; the interpolation method introduced in-

stead ("ad hoc autem inveniendum hanc artem adinveni labore multo", 159ra) is then wrongly thought to give better results than the tables do. Other numerical re-calculations, according to rules in the canons, may also lead our author to discern slight discrepancies with the tables, e.g. as concerns right ascensions, houses, and finding hour-of-day from solar altitude when this is compared to the inverse procedure. He computes the motion of the eighth sphere from both available tables (Toomer no.81, iii and ii), finds that the results differ, and decides to recommend the first table (150ra, §506).

Where calculation is not involved, the occasions for discussion are harder to guess at, and the likelihood greater that the arguments are taken over from other sources. Simplified geometrical reasoning is used for guessing at the precision of the canon that implies a constant proportion between the lunar diameter and the diameter of the earth's shadow (135ra-va, §424), and of the canon for finding the eclipsed part of the solar disk from that of the solar diameter (133va, §416; 136va-b, §431). The discussions are loose and partly colloquial and may well be our author's own. The same thing can be said about his critique of the Theorica Planetarum on a detail in the theory of Venus and Mercury (111rb-va, §292). Practical experience may have caused the pertinent criticism of the canon for correcting parallax (Sample F §380), including the argument from continuity. On the other hand, the recommendations of the Almeon-table (§8 above) were no doubt prompted by the canons, or by common opinion, as was certainly the note on up-dating the stellar table (Sample H §525).

11. The workaday problem of <u>correcting particular copies</u> of the tables is implied where the canons offer numerical methods as alternatives to the tables. Our author only once expressly considers the possibility, in connexion with the shadow-table (85rb-va, §147, "si velis igitur corrigere tabulam umbrae..."), giving instances of re-calculating two values. This is concluded with "haec igitur est compositio tabulae umbrae", which may show that correction was considered on a par with the more general task of <u>constructing tables</u> from the parameters. This possibility is mentioned a few more times, with rules lacking numerical examples, e.g. for tables of sines, right ascensions (76rb, §132), and oblique ascensions (85vb, §149-50; 86va-b, §156), prompted by the canons in the last case. In the last chapter, where sines are computed (154vb+), we are told "sed de isto ponam exemplum et docebo te etiam componere tabulas sinus, domino concedente" (158va). This is fulfilled for a few values, subsequently compared to the existing table of

sines, as mentioned in §10. Indeed, most of the other comparisons there touched upon may as well have been meant as running checks of copies whose textual basis was not too secure. - It may be said that John of Sicily multiplies the precepts for constructing or verifying tables, also including approximative methods suitable only for verification. Neither he nor our author apparently did construct their own tables: thus in fact our author made do with the oblique ascension tables for the 7th climate (Sample A §141), and with the tables of houses "ad civitatem Toletanam, quia ad praesens alias non habui" (98rb,§220).

12. Our author repeatedly mentions that he has used some instrument to verify computations, notably in Sample H §526; later on he concludes this by affirming "hoc autem capitulum et eius operatio aequata sunt praecise per tabulas et per instrumentum verax, et ideo non sine labore" (154va, §534). The only such instrument anywhere named is the astrolabe, which was probably what the author used: indeed, having calculated the equatorial arc risen since sunrise, he adds "et idem invenies per astrolabium si instrumentum verax sit" (92va,§292); a computation of the ascendent from the hour of night is concluded with "et quod istae operationes verae sint, probes per astrolabium, vel per aliud instrumentum, sicut feci" (95ra,§206); after the reverse computation he just refers to an instrument (98va,§221). Users obviously understood such brief statements (including one more about a detail of operation, 154ra, §533), whether they had practice on the astrolabe or not; in any case the operations were standard in treatises on that instrument. - Some unspecified instrument is presupposed for taking altitudes: of stars, for finding geographical latitude; and of the sun, for finding the hour of day by subsequent calculation. All this is implied by the canons, and any common instrument may have served. - On the "instrument" for Mercury see Sample D. - In general cf. Benjamin & Toomer p.422-3.

13. The author states his position towards judiciarial astrology five or six times. Three of them must suffice for entertainment:

(147rb,§488, on *proiectio radiorum*:) Sive autem istud sit verum sive non, nescio, nec hoc credo esse negotii astronomi; sed artificis superioris forte interest hoc considerare.

(147va,§489, same subject:) In isto stat sententia canonis, sicut mihi videtur; sive autem hic aliquid veri dixi vel non, non assero, quia in hac materia parum vidi et nihil audivi: transcendit enim hoc negotium considerationem simplicis astronomi.

(151va,§517, *revolutio anni natalis*:) ideo partes istas volenti iudicare committo, cum ipse magis noverit ad quid valent.

Elsewhere one has: a short statement in the Preface; one referring parallax computation to astrology when not used for eclipses; and one like the last one cited. – I have seen a few similar remarks in William of England's Astrologia, but other technical texts usually do not bother much about setting off their subject-matter against astrology. Our author may just speak the truth in professing his ignorance: he did not condemn astrology, or he would not, earlier on, have given the astrological houses 13 columns of thorough and unreserved documentation. John of Sicily leaves out the present kind of remarks, or states them neutrally.

14. A point of terminology: In eclipse calculations our text pretty consistently employs the terms "argumentum latitudinis semel / bis vel secundo / tertio / quarto aequatum" for the moon's distance from the node, according to mean motion / in true syzygy / corrected for parallax in longitude / for parallax in latitude, respectively. Peter of Dacia uses about the same expressions in his Eclipsorium (§50-1, in one of the two manuscripts, late 1290s?), characterizing them as "argumentum latitudinis quod apud aequantes vocatur arg. lat. primo aequatum". As I mentioned in my preface to that work, the terms are also found in some of the eclipse predictions for 1292-5 included in a copy of William of St Cloud's Almanach (Vat.lat.4572), and later on in John of Lignières. They are, however, not from the canons, nor have I seen them in any other earlier work. I submit that they are peculiar to Paris as concerns our period, and possibly even to a restricted environment: indeed, John of Sicily leaves them out or paraphrases them arbitrarily.

15. As mentioned, John of Sicily is likely to have drawn upon our text, almost exhaustively, and with extensive supplements. Instances of correspondence are given in the Samples. A few further salient points are noted here; a detailed comparison will appear later.

John's numerical examples appear to show two sets of dates, one of them at 1291 Sep.1, noon (or A.H.689 complete + $8^m + 6^d$; noted by Poulle in DSB), used throughout the sections on chronology and planetary longitudes; the other one at A.H.690 complete, or about the start of A.D.1292, used for computing the next equinox, and for precession according to Thebit, which is found to be $9^o22'49''$ (P,214rb). John computes a solar eclipse on 1295 Nov."8" (P,208rb-va; Oppolzer 5970) and a lunar eclipse 5½ months earlier (P,210va+; Oppolzer 3875), both sought for within the Arab year 694. Apparently this was the first time since 1290 where John could succeed in finding both kinds of eclipse visible in Paris within one Arab year: I gather

this from the eclipse list with William's Almanach (§14 above) and from an impression of Oppolzer's diagrams, but it should be checked. Incidentally, John's lunar eclipse time is about 2 hours later than in the William-list, so apparently the figures were arrived at independently.

The precession value John really uses in the examples on planets is one of $9^{o}22'10''$ ("supponendo ipsum ad praesens", P 181rb; value used once more). This may simply have been taken over from the parallel passage in our text (106rb,§266), which shows the value $9^{o}22'20''$ for A.D.1290 running. John does not seem to use his own 1292-value (above); indeed elsewhere he puts no definite value to the precession, but supplies a lengthy discussion of it (Duhem 4,8-10). - This is probably because he knew of William of St Cloud's observations concerning the precession, made on 1290 March 12 (Duhem 4,17) and issued with the Almanach in 1292. At P,216ra (and in *Scripta Marsiliensis*, M,118vb), on finding the precession, one reads

Et si velis hoc idem subtilius agere, cum inveneris meridianam solis altitudinem minorem altitudine aequinoctiali per aliquot minuta - ut si altitudo meridiana in aequinoctiali fuerit 41 graduum et 12 minutorum, in 12'a vero die Martii reperias meridianam altitudinem esse 40 graduum 54 minutorum - vide differentiam inter eas, quae est 18 minutorum; et pro quolibet minuto adde super meridiem 12'ae diei unam horam, et habebis tempus et horam quo sol erit in aequinoctiali. Ad illud ergo tempus quaere locum eius in octava sphaera, et operare ut dictum est.

The observed solar altitude is the same as William's; for the co-latitude of Paris William gave $41^{o}10'$, which John does use elsewhere. John never quotes William's final result of $10^{o}13'$ for the precession. A likely guess is that John composed his work from start to finish, learning of some of William's results soon enough to eschew the obsolete value for the precession, and to compose his long digression on the subject; but nothing except John's partial silence seems to show that this happened before 1292.

All this does not serve to date John more precisely than was done by Poulle, that is, probably at late 1291 and 1292, the dates of John's examples, and at least after Sep.1290, where our author's eclipse calculations were outdated. It does show that our text does not depend on John. Indeed, apart from their probable ages, our text is ignorant of William's results, giving a different latitude for Paris and knowing only of Thebit's theory of precession (and possibly Ptolemy's, Sample H §525). For two further indications, if any are needed, see to Sample F and H.

It is harder to show that our text is not simply John's own earlier version of his commentary. The most conspicuous argument seems to be one of style: indeed, John's mode of writing tends to be ornate, never using col-

loquialisms, nor the personal form of address (e.g. Sample G), nor phrases of modesty such as the ubiquitous "salvo iudicio melioris". On the other hand, the plain style of our text extends to the last section on sines; and in the manuscripts where a fragment of this section is appended to John's work (§3 above), it is preceded by a note implying that John is not the author. - One may also notice that our author professes his detachment from astrology, and treats some of the relevant sections perfunctorily (§13 above), whereas John does a lot to fill out the missing parts. Thus, if our author is John, he had got up the subject, or the recipients' attitudes had changed drastically, or he had left Paris. - This may not disprove that our text is a reportation of an earlier oral version by John. Of course I should like our worthy author to be Peter of Dacia, but there is no positive evidence whatever to prove this.

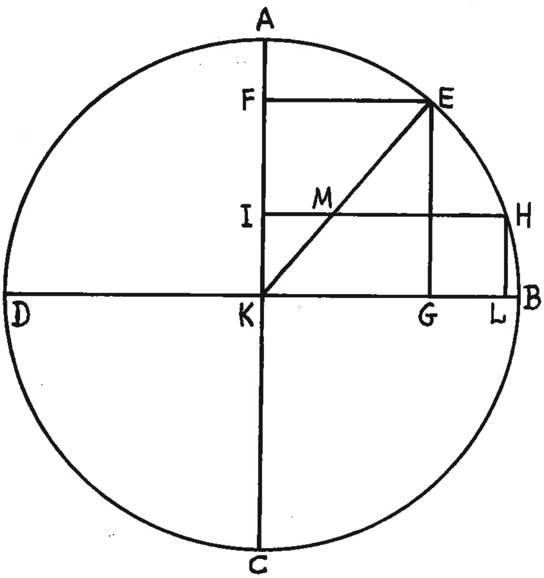
16. Samples of text. Italics are used for the wording of the canons, or what may count as it, without warranty for precision.

A. 84ra-vb; diagram re-drawn from one at 83vb. Text of the canons, see also Curtze p.349. - Finding oblique ascension of Aries, at the horizon of Paris, from sines. - For the geographical latitude l and the declination d of the end of Aries, the difference p of the right and oblique ascensions of Aries can be found as

$$\text{sinus}(p) = (\text{sinus}(l)\ \text{sinus}(d)/\text{sinus}(90^{\circ}-l))(150/\text{sinus}(90^{\circ}-d)),$$

where the sines are to base 150 as elsewhere in the canons. The diagram and rectilinear demonstration of §138 seem purely mnemotechnical and are typical of our text, cf. §9 above. - John of Sicily (P,165ra-va) has two demonstrations, one of them resembling our piece supplemented with an extra pair of similar triangles, the other one using the cada-figure (theorem of Menelaos; neither term mentioned), as is done e.g.in the anonymous contemporary text printed by Curtze p.360ff. No relationship between these demonstrations is expressly recognized. - Our text begins with a division and a paraphrase of the canon (83ra-va,§134-7). Then:

(§138) Demonstratur[1] autem hoc negotium communiter sic: sit colurus solstitiorum circulus ABCD; polus autem meridianus sit C, septentrionalis autem A; colurus autem aequinoctiorum[2] sit linea AC, aequinoctialis autem DB[3]; latitudo regionis sit arcus AE, cuius sinus est linea EF; residuum latitudinis de 90 sit arcus BE, cuius sinus est linea EG vel FK[4]; declinatio arietis arcus BH, cuius sinus est linea HL vel IK; residuum declinationis gradus de 90 sit arcus AH, cuius sinus est linea IH parallela aequinoctiali, transiens per gradum zodiaci scilicet ultimum arietis, cuius ascensiones quaeruntur. - Hic igitur sunt duo trianguli, quorum primus est KFE maior, secundus KIM minor, quorum anguli sibi invicem sunt aequales: quae igitur proportio KF ad FE, eadem est KI ad IM. Duc ergo FE[5] in KI et



productum divide per KF[6], et exibit IM, qui est pars paralleli IH, qui est sinus 4'us. Sicut igitur IH se habet ad IM, sic totus sinus rectus, scilicet KB, quod est 4'a aequinoctialis, se habet ad quandam partem sui, quam quaerimus. Ergo IH erit primum, quod tum proponebatur esse 4'm, et IM erit 2'm, KB 3'm: haec tria mihi nota sunt. Duc ergo KB in IM et productum divide per IH, et exibit quiddam, et est sinus cuiusdam portionis aequinoctialis; huius sinus quaeras circuli portionem, quae portio est differentia quae est inter ascensiones arietis in circulo directo et ascensiones eiusdem in circulo obliquo.

(139) Esto igitur quod tu velis scire, quantum cum toto ariete elevatur de aequinoctiali in circulo obliquo apud Parisius[7] Accipe igitur //84rb// latitudinem regionis ibidem, scilicet 48 gra et 13; cuius invenias sinum, aequando pro duobus introitibus ut supra, et invenies 111 m'a 50 2'a et 57 3'a. Deinde dictam latitudinem de 90 minue, et residui, scilicet 41 graduum et 47 minutorum, quaere sinum, et erit 99 m'a 56 2'a 41 tertia. Et erit iste secundus, prior autem primus; et est primus linea FE, secundus autem GE vel FK. - Deinde, cum ascensiones totius arietis velis, accipe[8] declinationem totius arietis, quae est, ut in priori capitulo ad circulum directum dicebatur, 11 gradus 31 m'a et 36 2'a; cuius sinum etiam quaeras ut supra, et erit sicut prius 29 m'a 59 2'a et unum tertium; et iste sinus erit tertius, et est iste sinus linea KI. Postea istam declinationem de 90 minue, et residui, quod est 78 gra 28 m'a et 24 s'a, quaere sinum, qui erit, sicut et supra ad circulum directum, 146 m'a 58 2'a 10 3'a; et iste sinus erit 4'us, qui designatur per lineam parallelam aequinoctiali, quae est linea IH, quae est sinus residui declinationis gradus. - Cum igitur isti sinus in se invicem multiplicari et per invicem dividi debent, ideo omnes in easdem fractiones reducas; et erit primus in tertiis 402657, et secundus 359801, et tertius 107941, et 4'us 529090. - Duc igitur primum in tertium, et exibunt in sextis 4346-3199237; quibus divisis per sinum secundum exibunt in tertiis 120798, quia sexta remanentia sunt plus quam medietas divisoris. Quibus multiplicatis per 150[9], quod est linea KB, exibunt in 4'is 18119700; quibus divisis per sinum 4'm exibunt in minutis 34 et remanent 130640, quae sunt 4'a; quibus reductis ad 5'a et divisis per 4'm sicut prius, exibunt 14; et remanent 431140, quibus iterum reductis ad sexta et divisis iterum per 4'm[10] sicut prius, exibunt //84va// 49[11] tertia, quia pro sextis remanentibus oportet accipere unum. - Sinus igitur inventus est <34 m'a> 14[12] 2'a et 49 tertia; cuius invenias circuli portionem, et erit 13[13] gradus 11 m'a 55 2'a 17 3'a; et haec portio est differentia duarum ascensionum arietis, in circulo scilicet directo et obliquo.

(140) Hanc igitur portionem demas, sicut dicit canon, *de* ascensione *arietis in circulo directo*, scilicet de 27 gradibus 53 minutis et 50[14] secundis, et *remanent* 14 gradus 41 m'a et 55[15] 2'a et 43 3'a, et haec *est*

elevatio vel ascensio arietis *et piscium* in circulo obliquo. (--- Then a piece on finding the ascensions of the other signs. The section concludes at the end of §141: ---) Si autem tabula[16] in minutis cum hac operatione non concordat penitus, hoc est quia factum est ad Parisius, tabula[17] autem ad 7'm clima est supra me-//84vb//dium eius; item et quia tabulae climatum compositae videntur esse super declinationem solis secundum Ptolomaeum[18], sed ego operatus sum cum declinatione solis secundum Almeonem, quae[19] verior est secundum quod dicit canon.

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[1]-trac(i)o [2]-tiarum [3]ob [4]fa [5]kf [6]fe [7]par() [8]-p(er)e [9]50*a.c.* [10]4 [11]44 [12]24 [13]12 [14]*n.l.* [15]55,43:52,93 [16]-lae [17]-lae [18]-omei [19]quia*.c.*

B. 89rb-vb. - Finding oblique ascensions of degrees of the ecliptic ("gradus aequales") beginning at Aries, by interpolation between previously computed values for integer signs. Criticism of linear interpolation. - Corresponds to John of Sicily (P 170ra-b), who has a different example mixed with the paraphrase.

(168) *Si vero reducere volueris*: Postquam auctor docuit per gradus aequales invenire gradus ascensionum, nulla[1] ascensionum supposita, docet hic consequenter, ascensione totius signi supposita, ascensiones alicuius partis determinatae illius signi zodiaci invenire. Et primo facit <hoc>, et secundo docet huius conversam, cum dicit *Si autem volueris convertere*.

(169) Primo dicit sic: *si volueris reducere gradus aequales in gradus ascensionum*, id est si volueris [scire] invenire gradus aequinoctialis correspondentes gradibus zodiaci datis: si velis hoc *per numerum* calculando, scilicet *absque tabula*, tunc *gradus quot velis*, scilicet *aequales*, *multiplica in gradus elevationum signi eiusdem* totius, supple; *et collectum divide per 30*, qui sunt gradus aequales cuiuslibet signi, *et exibunt gradus ascensionum*. Et si post divisionem *remanserit* aliquid dividendum, *multiplices* illud *per 60*, et productum *divide* ut prius *per 30, et exibunt minuta*; quibus ad gradus prius exeuntes additis, *habebis* ascensiones *graduum* propositorum, et minutorum, si cum gradibus aequalibus fuerint minuta.

Sint gradus aequales 20 gradus tauri et 20 m'a; quod reducatur ad m'a, et erunt 1220. Istud ergo multiplices per ascensionem totius tauri in minutis acceptam, quae sunt 1121, et exibunt in secundis 1367620; quae dividas per 30 gradus aequales, et exibunt secunda sicut prius, scilicet tot 45587; de decem autem remanentibus nihil cures, sed tot secunda, quot iam exiverunt, sunt ascensio graduum quaesitorum, 20 //89va// scilicet tauri. Haec ergo ad gradus et minuta reducas, dividendo per 60, et exibunt in fine 12 gra et 39 m'a et 47 2'a; et haec sunt portio aequinoctialis quae elevatur ad 7'm clima cum 20 gradibus et 20 minutis tauri.

(170) Sed tamen, si[2] intraretur ad tabulas septimi climatis cum 20 gradibus tauri et 20 minutis, solum haberes 11 gradus et 58 m'a et 20 secunda, ita quod erratum est in operando per capitulum istud fere ad 40 minuta in proposito. - Causa autem erroris est quia in isto capitulo supponitur quod, quanta est ascensio unius gradus signi alicuius, tanta sit et cuiuslibet alterius gradus illius signi. Quod manifeste falsum est, quia ascensio primi gradus tauri est 33 m'a, ascensio autem ultimi gradus eiusdem est 43 m'a. - Quod autem aequalitas ascensionum singulorum graduum hic supponatur, patet, quia[3] vult quod gradus aequales signi dati multiplicentur per ascensiones totius signi illius, et quod productum per 30 gradus aequales dividatur. Quasi auctor sic argueret: sicut se habent 30 gradus

aequales signi[4] ad gradus datos, sic ascensiones totius signi illius ad quandam partem sui; quae argumentatio non tenet nisi in proportione uniformi partium utrorumque totorum adinvicem. - Esto enim quod haec tria, scilicet A,B,C, valeant sex: tria igitur est unum totum et sex aliud sibi correspondens. Si igitur A valet unum, B duo, et C 3, non valet sic arguere: "sicut se habet totum A,B,C ad duo, scilicet A,B, sic <sex> se habent ad quandam partem //89vb// sui; sed A,B,C habet se ad 2, scilicet A,B, in proportione sexquialtera; ergo sex se habebunt ad partem sui correspondentem, AB, in proportione sexquialtera". Haec argumentatio concludit oppositum posito, quia concludit quod, sicut 6 correspondent 3, scilicet A,B,C, sic 4 duobus, scilicet A,B, cum tamen positum est A et B valere 3, quia A unum et B duo. Argumentatio autem supponit quodlibet illorum trium, scilicet A,B,C, valere duo; et ita consimiliter est in proposito. - Haec eadem est causa quare, in operando de sinibus[5] per kardagas vel e converso, non provenit idem operando cum tabulis et sine tabulis. Et istud nota diligenter, quia hic latet hamus, etiam magnis.

(171) *Si autem volueris convertere*: docet e converso ascensioni datae invenire gradus aequales correspondentes. Dicit sic: *multiplica gradus ascensionis* datae *in 30*...

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[1]ulla() [2]si: *in mg.* [3]quod *a.c.* [4]dati *add. & del.* [5]finibus

C. 99vb-100va. Text of the canons, cf. Curtze p.342. - Finding altitude a from shadow (=umbra(a) = 12 cot a), thus:

$$\text{sinus}(90^{\circ}-a) = 150\ \text{umbra}(a)/(12^2+\text{umbra}^2(a))^{\frac{1}{2}}.$$

Our passage had started at 99rb with a paraphrase and a demonstration on a figure. I reproduce the example following, which contains: (§228) a square-root extraction echoing Sacrobosco's Algorism; (§229) an interpolation method for squaring; and (§230) a method for square-roots, invented apparently by the author, on 1289 Aug.5 (cf.§5 above). In the last case, the divisor of 176 is in effect defined as the last subtrahend used in the root-extraction procedure, for reasons I cannot guess at: John of Seville (Algorism, Boncompagni p.77-8) has a similar method with the correct divisor, which is double the root found. At 155rb the text gives the square root of 12960 as 113;17,2,48, obviously by this method (divisor 669), whereupon the method is abandoned (§10 above). - John of Sicily repeats these examples (P,176ra-va) but leaves out, i.a., the details of calculation in §228 and the dating in §230.

(228) Ponatur in aliqua hora umbra esse 20 puncta et 47 m'a. Quorum accipias quadratum, ducendo 21 in se ipsa, ac si punctum ultimum esset perfectum, quia sic faciendo bene venietur ad aequalitatem: habebis autem in quadrato umbrae 441. Cui addas 144, quae sunt quadratum status rei, et habebis in quadratis utriusque 585 puncta.

De quibus extrahas radicem quadratam, inveniendo primo digitum scilicet 2 sub ultima figura versus sinistram, quia illa et est ultima et est loco impari ultimo. Duc ergo digitum illum in se, et productum, scilicet 4, deleas de 5 supraposito. Deinde dupla illum digitum primum, et duplum eius, scilicet 4, pone anterius sub 8, et digitum primum, qui est[1] subduplum[2],

ponas sub suo duplo, scilicet sub 4. Deinde sub prima figura, scilicet sub 5, invenias quendam digitum, et erit 4, qui ductus in duplatum et etiam semel in se evacuabit totum suprapositum, praeter 9; quae dimittantur pro nihilo, //100ra// quia digitus ultimo inventus, scilicet 4, non posset mutari in 5, ita quod radix ad unum augmentaretur [ad unum], nisi pro 50, sicut patet habenti modum extrahendi radicem. - Et ideo dicas quod radix quadrati totius est 24, scilicet digitus ultimo inventus praepositus subduplo; quam serva.

Deinde per 150 minuta multiplices umbram datam, scilicet 20 puncta et 47 m'a, redigendo eam primo ad minuta, et exibunt secunda scilicet[3] 187050; quae dividas per minuta radicis, quae sunt 1440, et exibunt 129 minuta; et remanent 1290 2'a, quibus reductis ad tertia et divisis iterum per minuta radicis eiusdem, exibunt 54 2'a fere. Et haec minuta et secunda sunt [sinus] quidam sinus, cuius quaeras portionem, et erit fere 60 gradus; quam portionem minuas de 90, et residuum, scilicet 30 gradus, est altitudo solis ad horam illam in qua[4] accipiebantur puncta umbrae. Est igitur solis altitudo 30 gradus, cum in umbra rei sunt 20 puncta et 47 m'a.

(229) Ad praecise autem operandum in istis, nota diligenter modum istum, quia accipies puncta umbrae cum suis minutis, et eorum, tam punctorum quam minutorum simul, quadratum hoc modo invenies: accipies enim primo puncta, et ea ducas in seipsa absque minutis, et habebis quadratum punctorum absque minutis. Deinde etiam pro minutis, quae sunt cum punctis, addas punctis eisdem unum, et aggregati sume[5] quadratum. Deinde de utriusque quadrati differentia tantam partem primo quadrato addas, quanta pars minuta quae sunt cum //100rb// punctis[6] sunt de 60; et quod provenerit[7] est praecise quadratum totius umbrae.

Verbi gratia, umbra accepta prius fuit 20 punctorum et 47 minutorum. Accipe igitur quadratum de 20 punctis, scilicet 400 puncta; item accipe quadratum 21 punctorum, quod est 441; de quorum differentia, quae est[8] 41 puncta, partem proportionalem accipias secundum proportionem 47 de 60. - Sicut igitur 60 se habent ad 47, sic se debe[re]nt habere 41 ad quandam partem sui, quae quaeritur. 60 igitur erit primum in quaerendo istam partem, et 47 2'm, et 41 tertium: duc ergo secundum in tertium, et productum, scilicet 1927 m'a, divide per primum; et exibunt 32 puncta et 7 m'a, quae addas ad puncta quadrati primi, quod est minus, et erunt puncta quadrati umbrae 432 <et 7 m'a.

Quibus addas 144, et habebis puncta 576> et cum hoc 7 m'a.

(230) De quibus extrahas radicem, et erit 24, nihil de punctis remanente. De 7 autem minutis remanentibus sic caute operaberis: resolve ea in 2'a scilicet tot 420. Deinde accipe digitum ultimo inventum in extractione radicis, et eum praeponas[9] duplato, per hunc modum "44". Deinde duc primum in secundum, et productum ponas supra secundum, et deinde duc primum in seipsum, per modum quo fecisti in extractione radicis; et provenient 176. - Per quem numerum dividas illa 420 2'a, et exibunt 2 2'a, quae sunt addenda ad radicem. Deinde secunda remanentia resolve[10] in 4080 tertia, et productum divide ut prius per 176, et exibunt 23 3'a, remanentibus 32 tertiis, de quibus nihil est curandum. Radicem igitur qua-//100va//drati propositi scias esse 24 puncta duo 2'a et 23 tertia.

Credo autem firmiter modum istum inveniendi radicem praecise cuiuslibet numeri inventum fuisse anno domini 1289 die beati Dominici.

(231) Per hanc radicem ad idem genus redactam, scilicet ad tertia, dividas <quod provenerat> ex ductu umbrae in centumquinquaginta, ad 4'a redactum, et exibunt 129 m'a, remanentibus tot 4'is scilicet 4625553; quibus redactis ad tot quinta 277533180, ea dividas ut prius, et exibunt 53 2'a, remanentibus adhuc quintis tot scilicet 2773601; quibus redactis ad sexta et divisis ut prius, exibunt 32 tertia, remanentibus tot sextis scilicet

523484, de quibus nihil cures. Est igitur sinus exiens[11] in toto 129 m'a 53 2'a et 32 3'a. Per quem invenias eius circuli portionem, et erit aequando 59 gra 59 m'a et 29 2'a; quibus subtractis de 90 gradibus, quod est tota 4'a altitudinis, remanet altitudo solis, 30 gradus et solummodo 31 2'a. - De hac aequatione non oportet dubitare, quia praecisius non fiet.

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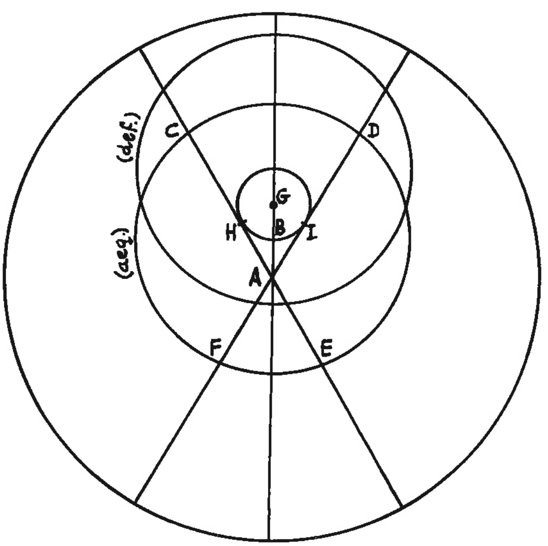
[1]iam [2]-plam [3].a.(=?) [4]quam [5]su(m)me [6]-ctorum [7]-ueniu(n)t
[8]erit *a.c.* [9]p(ro)p. [10]resoluta [11]exerus

D, 111va-112ra. Diagram re-drawn from one at 112rb. - Machine for simulating the motion of Mercury's apogee. - The citations are certainly from the Theorica Planetarum Gerardi (e.g. København K.B., add.447,2°, 53vb). There may also be points of touch with Campanus' Theorica: thus our manuscript figure looks like Campanus' (Benjamin & Toomer p.288 fig.14) except for the point-names and the epicycle; but Campanus' description (ibid., Sec.V 234ff) is not the source of ours, and does not specify mobile parts. - The phrase "motus mirabilis" is used by Campanus (V 53), but could be standard. The question is whether there is a pause when the motion changes its direction: ample references (since Arist.Phys.8,262a12) ibid., p.405-7 n.10. Our author seems to think there is a pause. - About the first half of the paragraph was used by John of Sicily (P 192rb-va), who thereupon added or restored the epicycle; elsewhere he also supplemented the Mercury-section with gleanings from Campanus.



(296) Ad verificandum autem dicta auctoris Theoricae Planetarum de motu Mercurii mirabili, cum imaginatio seu in//111vb//tellectus eum de difficili capiat, fiat instrumentum ad hoc ostendendum faciliter hoc modo: fiat asser planus, in quo describatur circulus orbis signorum cum sua diametro. Deinde, quia centrum huius circuli est centrum terrae, quod vocetur <A>, describatur alius circulus infra circulum istum orbis signorum, quantaecumque quantitatis tu velis, supra punctum aliquod distans quantum velis a terra in diametro. Et[1] vocetur centrum illud B; circulus autem iste vocabitur aequans Mercurii, et vocetur iste circulus CDEF. Et iste circulus est immobilis, et ideo debes eum sicut dixi depingere, ut semper teneat eundem situm[2]. Deinde, de quacumque materia velis, facias unum circulum continentem solum unam lineam circularem et unam di-

ametrum, in qua diametro semper notari[3] poterit centrum circuli illius; et iste debet esse eiusdem quantitatis cum circulo picto. Deinde in ipsa diametro signetur punctum in tanta distantia a centro circuli, quanta est distantia centri aequantis depicti a centro terrae. Deinde etiam in diametro circuli depicti signetur punctum in tanta distantia a centro aequantis, quanta est distantia centri aequantis a centro terrae, sicut est punctum G. Deinde circulus separatus in puncto signato iuxta centrum suum conclavetur cum assere praedicto in puncto iam signato iuxta centrum aequantis: conclavetur, inquam, sic ut moveri possit. - Et videbis quod centrum illius circuli mobilis in motu suo describit quendam parvum circulum, scilicet BHI, et transibit iste circulus per centrum //112ra// aequantis, quod est B. Et[4] circulus iste mobilis erit signum deferentis Mercurii. - Deinde a centro terrae exeant duae lineae, contingentes utrimque parvum circulum; et istae duae lineae includunt infra se portionem quandam aequantis, quae portio est arcus CD, superius, et aliam inferius, scilicet EF. - Et videbis quod aux deferentis numquam exit portionem CD, sed semper movetur infra capita linearum contingentium; et per consequens oppositum augis numquam exibit portionem EF. Et ideo dicit auctor Theoricae quod centrum epicycli Mercurii, existens infra arcum EF, est semper in opposito augis quamdiu ibi fuerit. - <**?> sed huic adhuc non consentit animus. Ideo ad huius evidentiam ligetur unum filum in puncto centri terrae, et ponatur ipsum filum super centrum deferentis mobilis; et semper cadet in augem necessario, ita quod, cum centrum deferentis in parvo circulo venerit ad punctum <I> contactus circuli parvi cum alterutra linearum, tunc aux deferentis est in puncto aequantis D. Deinde, filo iam iacente [supra centrum de] supra centrum I deferentis, moveatur deferens versus dexteram: diu etiam semper manebit centrum deferentis sub filo; et per consequens aux deferentis manebit in eodem puncto vel respiciet idem punctum aequantis. - Unde breviter per instrumentum istud verificare poteris omnia dicta in Theorica de motu Mercurii.

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[1].et. [2]scitum [3]vocari [4]*n.l.*

E. 122va-123ra. - Eclipses: finding lunar velocity between mean and true syzygies. At the time of mean syzygy, the true sun and moon (or its opposite) are at an elongation ("longitudo"); and from then till the time of true syzygy, future or past, the moon has to traverse 13/12 of that elongation. To find a mean velocity for the moon over this interval, one has to enter the table Toomer no.56 with some value for the moon's distance from the apogee of the epicycle ("argumentum lunae"). This value is now chosen as the value at mean syzygy, plus or minus half of 13/12 of the elongation, for the reasons to be stated. - Our text may have a precursor in Albattani ch.42, or in the Lesser Almagest (Vat.Reg.lat.1261,40r), which at this point seems to depend on the Toledo Tables, mentioning them a little farther on. - John of Sicily keeps close to the phrasing, with some abridgment (P 198ra-b, text in Pedersen 1978 p.88(D)); the "causa"-note is also in the Scripta Marsiliensis (M,115vb) in John's wording. A later successor could be Peter of Dacia's Eclipsorium, §101 (Pedersen 1983 p.498, cf.id.1978 p.78).

(362) *Vel aliter*: docet invenire motum lunae aequalem in una hora praecisius quam prius. Et primo, quia tabula supposuit lunam non moveri nisi motu epicycli, corrigit errorem illum primo; et secundo, quia adhuc isto rectificato supponitur[1] lunam motu proprio in epicyclo absque motu epicycli aequaliter moveri in orbe signorum[2], docet errorem illum corrigere, cum dicit *Invento autem motu lunae*.

(363) Et quia errorem primum rectificare docet per additionem vel deminutionem medietatis longitudinis et duodecimae ad argumentum lunae vel ab argumento lunae, cum hoc contingit dupliciter fieri, ideo additionis illius vel demi-//122vb//nutionis dat duos modos.

Dicit igitur: *Vel aliter, ut motum lunae aequalem invenias in una hora subtilius et certius, longitudinem quae fuerit inter solem et lunam in duo media partire*, id est divide, *et <uni> me<dietati>*[3] *eius adde* suam *duodecimam*, id est, duodecimam solius medietatis adde ipsi medietati; et iste est modus primus. - Vel longitudinem cum 12'a dividas scilicet in duo media, et iste est modus secundus. - *Et quod collectum fuerit*, scilicet in altero modorum duorum, adde *argumento lunae si fuerit longitudo solis*, quia iam adhuc futura est vera coniunctio, *vel ab* eodem argumento *minue*, scilicet acceptum alterutro istorum modorum, *si eadem* longitudo *fuerit longitudo lunae*, cum iam praeteriit coniunctio vera. *Et hoc erit argumentum* lunae aequatum, *per quod* scilicet *motum lunae aequalem in una hora debes invenire*, scilicet intrando cum eo *ut dictum est* ad tabulam motus lunae aequalis in una hora, quae crescit per 6 gradus.

Causa autem quare, ad habendum motum lunae aequalem in una hora[4], oportet supra argumentum lunae addere, vel ab eodem subtrahere, medietatem longitudinis et duodecimae, est haec, ut videtur mihi, quia luna fere tantum arcum epicycli in quolibet tempore dato deambulat, quantum centrum epicycli sui deferentis vel orbis signorum. Et quia, completo toto motu longitudinis et 12'mae, poneretur luna<m> secundum se nihil esse motam, nisi aliquid sibi (*sc.* argumento) adderetur; item, si tota longitudo cum 12'a sibi adderetur, iam in tota longitudine poneretur in orbe signorum plus vel minus moveri quam movetur, //123ra// quia minus movetur in auge quam ad 30 gradus distans ab auge - loquor de motu suo in orbe signorum per motum centri epicycli - et[5] ideo, addendo argumento lunae medietatem longitudinis et 12'mae, ponemus lunam esse in puncto medio inter punctum epicycli, a quo movetur in initio motus centri epicycli per longitudinem cum 12'ma, et punctum epicycli in quo erit in fine motus longitudinis et 12'mae. Et ideo contingit ut, de quanto attribuitur sibi plus vel minus de motu ante medietatem longitudinis et 12'mae percursam, de tanto minus vel plus e converso in medietate secunda longitudinis et 12'mae sequetur eam moveri; et ita, de quanto ad medium erratur a principio, de tanto erratum a medio ad finem corrigetur, ut in fine mota sit quantum debet.

(364) Et istud, licet subtile, patitur adhuc defectum, quia supponitur lunam secundum se aequaliter moveri superius in epicyclo et inferius, dato quod epicycli motus circumscribatur: et ideo auctor, cum dicit *Invento autem motu lunae*, docet errorem illum corrigere...

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[1]sup: *in mg.* [2]signo [3]e.u.m.: *in mg.*; undecim *a.c.* [4]hor«a»
[5]et: *adest saepius*

F, 125va-126va. - Solar eclipses: The lunar parallax ("diversitas aspectus", both in longitude and latitude) has been extracted from the tables (Toomer p.97ff.). It is now to be corrected for the moon's place on the epicycle, by entering the table of *aequatio* (Toomer no.79, "circulus

brevis"), which yields *minuta proportionalia* (*m*) between 0 and 12. These are a measure of the moon's distance from the observer such that, if the parallax found is p, then the correction is $\pm p \cdot m/12$ (really $+p \cdot m/60$, see below). - §379 concerns the argument with which to enter the *aequatio*-table, and the terms used may be compared to Sample E with note. §380 discusses the starting-point of the correction (apogee or mean longitude: the former according to the heading of the table Toomer no.72; cf.Toomer p. 100). - The discussion assumes a divisor of 12. This is censured by John of Sicily, P 207va (text, Pedersen 1979 p.104), and both he and the *Scripta Marsiliensis* generally use 60. The sole exception is the passage corresponding to our §380 (John, P 201rb; *Scripta*, M 116rb), where all witnesses show the value 12. At this point, then, both John and *Scripta* are likely to depend on our text. - §379 corresponds to John, P 199rb-va, with the normal value of 60 for the divisor.

(379) *Si autem fuerit ultra vel infra*: docet verificare diversitatem aspectus utriusque pro loco lunae, in quocumque horā coniunctionis verae fuerit. Dicit igitur quod, *si* luna *fuerit ultra vel infra*, id est, vel superius vel inferius in epicyclo et non in alterutra longitudinum mediarum, //125 vb// tunc *cum argumento lunae*, scilicet aequato per additionem longitudinis et 12'mae solis et lunae, *tabulam aequationis eius*, scilicet lunae, ingredere, quae tabula est proximo post aspectus, parva et oblonga, ut patet, *et accipies quae in directo eius inveneris minuta proportionalia, et multiplica ea in minutis longitudinis et latitudinis divisim*, et, supple, productum divide per 12, *et quod inde provenerit minue unumquodque de suo genere, scilicet minuta longitudinis de longitudine et minuta latitudinis de latitudine*, minue, inquam, *si fuerit argumentum in medietate*[1] *superiori* epicycli, *vel adde illud, si fuerit in* medietate[2] *inferiori; et* tunc *habebis minuta latitudinis et longitudinis certissima ad diversitatem aspectus lunae in eadem hora*, scilicet coniunctionis verae.

Nota primo hic quod argumentum, cum quo hic intrandum est pro minutis proportionalibus, est argumentum aggregatum ex argumento primo invento ad horam coniunctionis mediae et ex tota longitudine cum 12'a, quia in vera coniunctione tantum erit, si media coniunctio praecedat veram; vel istud argumentum est illud quod remanserit post subtractionem totius longitudinis et 12'mae ab argumento invento cum tempore coniunctionis mediae, si coniunctio vera praecedit mediam. Argumentum enim lunae vel plus vel minus erit ad coniunctionem veram quam ad coniunctionem mediam, si vera a media differat, et maior vel minor de tanto arcu epicycli, quantus <est arcus> longitudinis cum sua 12'a: quoniam, quantum arcum luna pertransit in orbe signorum motu centri epicycli, tantum arcum, modico minus, epicycli trans- //126ra//it luna motu proprio in epicyclo. Et ideo pro inveniendo descensu lunae ab auge, qui descensus significatur per minuta proportionalia, intramus cum argumento lunae ad coniunctionem veram. - Et quod istud quod dixi est argumentum lunae ad coniunctionem veram, probes per tabulas argumenti lunae, argumento lunae, ad coniunctionem mediam invento, addendo vel subtrahendo argumentum lunae inventum in tabulis argumenti medii lunae.

(380) Sed ego credo firmiter quod auctor hic loquitur contra rationem, vel ego eum non intellego. Si enim tabula supponat lunam esse in longitudine media sui epicycli, ergo ad tabulam aequationis aspectus lunae non

est intrandum cum argumento lunae, cum illud computatur ab auge; sed sic esset faciendum, si tabulae diversitatis aspectus supponerent lunam esse in auge epicycli. - Item, si diversitas aspectus inventa et aequata pro partibus horae et pro parte signi esset ad lunam existentem in longitudine media epicycli, <si>[3] tunc luna esset in auge, multo deberet diversitas aspectus esse minor. Sed secundum canonem eadem esset: quod patet, quia dicit quod partem proportionalem, de qua dictum est, oportet minuere[4] a diversitate in utroque aspectu, si luna fuerit superius in epicyclo; sed lunā existente in auge nulla erit pars proportionalis, quia non erit aliquod minutum. - Item et manifeste patet quod pars illa proportionalis diversitatis in utroque aspectu maior erit, luna magis distante ab auge. Et sic sequetur quod, luna existente prope longitudinem mediam ad unum gradum superius fere, ad medietatem erit diversitas in utroque aspectu minor, //126rb// et ipsa etiam distante ad unum gradum a longitudine media inferius, erit eadem diversitas plus quam in medietate maior quam quando est in longitudine media: talem autem permutationem et tam grandem ita subito accidere est inconveniens. - Item et, luna existente in opposito augis, praecise duplo maior erit diversitas in utroque aspectu quam in longitudine media, <sed>[5] in auge, sicut dictum est, <est> aequali<s>. - Item ex dictis patet, si vera sunt quae dicit canon, quod maior est diversitas in utroque aspectu, luna existente in auge, quam prope longitudinem mediam in sursum. - Quae omnia sunt absurda et contra rationem et contra sensum.

Haec sunt quae me hic faciunt dubitare, et ideo, salvo iudicio melioris, dicendum est quod tabulae supponunt lunam esse in longitudine longiori, id est in auge, quia hoc posito nullum accidet inconveniens.

Operandum autem est tunc isto modo, quia intrare oportet cum argumento lunae ut prius ad tabulam aequationis diversitatis aspectus lunae; et illud, quod ibi inventum fuerit de minutis proportionalibus, multiplicabis in minuta longitudinis et latitudinis divisim, et productum dividendum sicut prius per 12; et exibunt partes proportionales, quae semper addendae sunt diversitatibus aspectuum prius inventorum, scilicet quodlibet ad aliud sui generis. - Et cum hoc dicto meo concordat titulus tabulae diversitatis aspectus ad 7. clima, si[6] advertas.

Istud[7] autem passum, quicumque fueris, diligenter ponderes[8], et ponderando examines utrum canoni vel mihi sit adhaerendum, quia si hic erretur, gravissime errabitur. Nec[9] video[10] maius periculum in aliqua operatione quae tangit //126va// eclipses quam hic: quia, si secundum viam canonis inveneris quod sol totus eclipsetur vel eclipsari deberet[11], operando secundum viam meam non fiet eclipsis in 5., 6. vel 7. climate. Et ideo videas utrum simplici dicto credendum sit magis quam rationibus.

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[1]i(m)mediate [2]mdiatetate [3]*ras.?* [4]*in spat.vac.* [5]*n.l.* [6]*n.l.*
[7]*sic!* [8]-dens *a.c.* [9]*n.l.* [10]in deo [11]-bent

G. 148rb-va. - Apparitions and occultations. Example of note formed as an objection, cf. end of §6 above.

(496) *Cum vero volueris scire ortum*: determinat hic de apparitione et occultatione planetarum. Et primo facit hoc in grosso, et secundo magis exquisite, cum dicit *Cum ergo hoc tibi placuerit.*

(497) Dicit primo quod, *cum volueris scire ortum cuiusvis trium superiorum, quando praetermissus a sole inceperit* in *mane apparere, considera argumentum eius aequatum;* quod si *fuerit prope 20 gradus, erit* planeta *incipiens apparere, exiens de sub radiis solis; occultari autem incipit atque tegi* sub radiis, *cum fuerit idem argumentum prope 340 gradus. Veneris*

autem[1] *et Mercurii apparitio orientalis erit, cum fuerit argumentum eorum prope 20 gradus.*

Contra diceres tu quod Venus et Mercurius, sicut et alii planetae, distantes[2] ab augibus epicyclorum suorum ad minus quam ad 180 gradus, per dicta semper apparent[3] post solis occasum; quomodo igitur Venus et Mercurius apparebunt in oriente, cum ipsorum argumentum fuerit circa 20 gradus, sicut auctor hic dicit? //148va// Constat enim quod non videbuntur, antequam sol circa aliquot gradus fuerit sub horizonte; cum igitur videantur, hoc erit prope horizontem in occidente et non in oriente. - Dico quod ad istud, exponendo hoc quod dicitur 'in oriente' vel *orientalis*: pro oriente planetae[5] et non oriente simpliciter totius caeli. Planeta enim inter augem et terminum aequationis maximae per praehabita dicitur oriri: hic enim 'oriri' est a sole elongari. Et iste est ortus qui vocatur ortus heliacus; et tu arguebas de ortu cosmico; et ideo non valuit instantia.

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[1] aut [2] distant [3] -ret [4] *immo* solis

H. 152rb-153ra. - Finding day-arc of Aldebaran from its declination, at the geographical latitude $48^{\circ}40'$ for the 7th climate. The declination of $14^{\circ}39'$ is computed according to the canon. Earlier on (146va,§483) Aldebaran had been assigned a declination of $14^{\circ}41'$, and other coordinates, from a table which is certainly Toomer no.82a, said in its heading to be valid for A.H.577 (cf. Poulle p.142 on John of Sicily); our §525 then updates the longitude for a time interval of "about 112 years" (cf.§5 above). John of Sicily omitted this comment, perhaps because he would not commit himself on the precession (§15 above). He repeats the procedure of §523-4, §526, with the same example (P 217vb-218ra), but omits the self-correction of our §526 (cf.§12 above), stating only the correct result. The "demonstration" of §527 is also taken over by John, who still does not refer to a figure but remarks that the reason can be seen from the figure on oblique ascensions (cf. Sample A for figure and a similar procedure).

(522) Subdit igitur auctor: *Quaere itaque sinum longitudinis planetae vel stellae fixae vel etc.*: quaere igitur sinum declinationis[1] Aldebaran, scilicet 14 graduum et 39 minutorum, et est 37 m'a 56 2'a et 3 <tertia, sive> 136563 tertia. *Deinde* declinationem istam *stellae de 90 minuas, et residui*, scilicet 75 graduum et 21 minutorum, quaeras *sinum*, et erit 145 m'a 7 s'a et 6 tertia, *qui erit sinus residui longitudinis*, id est declinationis, *stellae; serva* etiam *eum. Considera quoque sinum latitudinis regionis*, quae latitudo est apud 7'm clima 48 graduum et 40 m'orum[2], scilicet circa medium eius; huius autem sinus est 112 m'a 37 2'a et 45 3'a; *et eum sub primis duobus sinibus* signa. *Postea diminue latitudinem regionis de 90, et residui*, scilicet 41 graduum et 20 minutorum, *sinum*, qui est 99 m'a 3 2'a et 45 3'a, *sub aliis tribus nota, qui erit* vocatus, supple, *sinus residui latitudinis regionis.*

(523) *Multiplica itaque*: praemissis necessariis ad propositum investigandum, docet per ea propositum, scilicet moram stellae propositae supra terram, investigare. Et facit duo, quoniam primo docet invenire arcum aequinoctialis, quem ducit stella secum ab ortu suo ad eius occasum, et secundo ex eo elicit horas morae suae supra terram, cum dicit *Divide igitur*.

(524) Dicit primo: *Multiplica itaque sinum latitudinis regionis in sinum longitudinis*[3] id est declinationis, *stellae* propositae *ab aequinoctiali linea,* //152va// *et summam quae tibi provenerit*, scilicet 55371516795, quae sunt 6'a, *divide per sinum residui longitudinis stellae*, qui est secundus sinus. *Itemque, quod ex hac divisione provenerit*[4] scilicet 105989 3'a - nec curabis aliquid de sextis residuis, scilicet 107481, cum sint minus medietate divisoris - *duc in 150,* quae sunt sinus totus, *et* numerum inde *surgentem*, scilicet 15898350, quae sunt[5] 4'a, *partire per sinum residui latitudinis regionis, qui fuit ultimus; et sinus provenientis ex hac divisione*, scilicet 44 minutorum 34 secundorum et 48 tertiorum, *invenias circuli portionem,* et erit 17 gra et 25 m'a fere; *quam portionem addas* supra *180* gradus, cum *longitudo*[6] *stellae* acceptae *sit ab aequinoctiali septentrionalis; et quod fuerit post augmentum*, id est additionem factam, *est portio circuli stellae*, scilicet Aldebaran: portio, inquam, *diurna*, id est arcus qui de aequinoctiali elevatur ab ortu stellae ad eius occasum; et erit 197 graduum et 25 minutorum.

Divide igitur eam per 15, et habebis per quot horas aequales moretur super terram; et exponit se, dicens *id est, quot horae aequales transeant ab ortu eius usque in* ipsius *occasum*; et hoc ab initio huius capituli intendebatur[7] - Et morabitur supra terram haec stella, quae est Aldebaran, ad medium 7'mi climatis per 13 horas et 10 m'a, supposito quod ipsa sit in fine vicesimi octavi tauri, sicut scribitur in tabula.

(525) Sed hoc non est verum hodie, quia a tempore verificationis stellarum positarum in tabula fluxerant circiter 112 anni, qui large valent tempus motus stellae per unum gradum. Et ita dicatur secure Aldebaran esse circa //152vb// finem 29'ni gradus tauri; et ita etiam trahere potes motum stellae cuiuslibet, in dicta tabula positae, ad unum gradum ultra locum in quo invenitur in tabula.

(526) Et si advertere velis, comparando operationem istam ad id quod per instrumentum invenitur, invenies te errasse hoc modo operandi in 17 gradibus et plus: et ideo, cum dicit auctor portionem sinus inventam addendam esse vel minuendam 180 gradibus, glosabis sic: *portionem*, duplicatam scilicet. - Cuius ratio est quia illa portio est arcus, secundum quem stella tardius oritur quam gradus zodiaci, in aequinoctiali; et ad tantundem arcum stella etiam tardius occidit quam gradus zodiaci, in aequinoctiali; et ideo oportet portionem inventam duplicari: istud diligenter nota. - Sic enim operando invenies arcum diurnum Aldebaran esse 214 graduum et 50 minutorum, qui valent[8] 14 horas et 19 m'a.

(527) Et stat istud capitulum super quadam demonstratione duorum processuum, quorum primus est: sicut se habet sinus residui declinationis stellae de 90 ad sinum declinationis stellae, sic se habet sinus latitudinis regionis ad quendam sinum 4'm. Et ideo sinus residui declinationis stellae est primus, et sinus declinationis stellae secundus, licet e converso ordinantur in littera, et sinus latitudinis regionis est tertius. Et ideo multiplicamus sinum declinationis stellae per sinum latitudinis regionis, tamquam secundum per tertium, et productum dividimus per sinum residui declinationis stellae de 90, tamquam per primum. Et exit quidam sinus 4'us; qui non est quaesitus, sed per ipsum, et sinum residui latitudinis regionis de 90, et per sinum totum<, invenietur sinus quaesitus>. - Est enim secundus processus iste: sicut se habet sinus residui latitudinis regionis[9] //153ra// de 90 ad sinum, qui in primo processu invenitur, sic se habet sinus totus, scilicet 150 m'a, ad quendam quartum. Et ideo sinum in primo processu inventum multiplicamus per 150 m'a, [et] tamquam secundum per tertium, et productum dividimus per sinum residui latitudinis regionis de 90, tamquam per primum. Et exit sinus quidam, cuius quaerimus portionem; et hanc portionem intellego esse arcum medium qui est inter stel-

lam cum est in horizonte, oriens vel occidens, et aequinoctialem.
Ita credo hic esse arguendum et intellegendum, nec aliud mihi apparet.

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[1]del()c()onis [2]m'a [3]latit. [4]p(ro)u(er) [5].1. *add.* [6]-tudine [7]-bartur [8]val(et) [9]reg()i

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