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# William of Saint-Cloud:

## *Almanach Planetarum*

### An edition of the canons, a few samples from the tables, and a foray into the numbers

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## Contents



## Introduction

William of Saint-Cloud (Guillaume de Saint-Cloud, Guillelmus de Sancto Clodoaldo) was active in Paris around 1290, thus sharing time and place with such pre-Alphonsine astronomical writers as John of Sicily and Peter of Dacia. A succinct introduction to his work can be found in Poulle's article in *Dictionary of Scientific Biography*,[1] and a longer one in Harper 1966.

The *Almanach planetarum*, well-known as a rare source for detailed astronomical observations in the Latin Middle Ages, was prepared about 1292 (cf. §1 and §20 in the text or translation), and at least before

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[1] <http://www.encyclopedia.com/doc/1G2-2830904663.html>, retrieved 2014-03-23.

May 1293 (§21). It was widely quoted later, mainly for its equinox observations in 1290 (§5). Contemporary testimonies are in Peter of Saint-Omer (1293/4) and in Peter of Dacia (about 1300).[1]

The *Almanach* consists of an ephemeris of the Sun, Moon, planets, and dragon (here called "tables"), for the years 1292-1311, with an introduction (here called "canons" for brevity, though the explanation of the tables only covers §26-31). The following pages will present an edition and translation of the canons; a reconstruction of each observation described there; a few samples from the tables; and a summary analysis of the numerical material in both. A partial edition of the canons has already been published by Mancha (1992, for details see list of references).

The reconstructed celestial coordinates were kindly communicated to me by Dr. Claus Fabricius, Universitat de Barcelona. They ultimately rest on the JPL Ephemeris DE406, and on the Hipparcos catalogue as concerns the star Beta Scorpii.

William gives no details about his own calculations of planetary longitudes (except two rather hasty examples in §18-19). In fact, it has turned out difficult to reproduce them more precisely than within, typically, some minutes of arc. In the Appendix I list my calculations, for the use of anyone who can do better. They cover all the calculations in the canons, and three small samples from the tables, with statistics of the imprecisions in recomputing the latter. At least it is not in doubt that William used the rules for the Toledan Tables (*canones*, §20; quoted in the beginning of the Appendix), or some equivalent algorithms.

[1] Peter of Saint-Omer: *Semissa* §2,21, Pedersen 1983-84, II p. 694, quoting the corrections for the mean motions of Saturn, the Moon, Jupiter and Mars; *Semissa* §3,16, *ibid.* p. 699, quoting the motion of the eighth sphere as 10°10' for 1293 (10°16' in the *Almanach*). -- Peter of Dacia: *Eclipsorium* §58 (Pedersen, *ibid.* I p. 489) cites the motion of the eighth sphere as 10 1/3°. Another version of the *Eclipsorium* (Pedersen 1978, p. 34, §2,24) has the figure 10°22', this being the *Almanach* value for AD 1300. None of all these passages mentions William or the *Almanach*.

It turns out that all the observations described in the canons are realistic, and that the numbers appear to be well preserved (except the dating in §21). In this sense, the philological part of the edition has been done, bar calculation errors. Everything else (except for the *camera obscura* part, admirably treated by Mancha) remains to be explained, including how William arrived at his corrections for Saturn and Jupiter, and why they are different (note to §12). As a philologist I can only do this much, but I hope, once more, to have set the ball rolling.

Many thanks to Claus Fabricius, above, and to Christopher Schabel, University of Cyprus, for a much-needed correction of the translation. All errors are mine alone.

**Notation in the notes to the translation and in the Appendix:**

Times are specified as true solar time, which is for Paris (longitude 2°20'14" E), and is equal to the hour angle of the true Sun plus 12 hours.

The planetary longitudes computed from the Toulouse Tables are sidereal, cf. §5 "the tables established for the eighth sphere". Tropical longitudes, as used in the tables of the *Almanach* and in modern ephemerides, are designated as "in the ninth sphere". More details about using the Toulouse Tables can be found in the Appendix.

Notation of longitudes: <231°15'>, <231;15°>, <7s21;15°> and <Sco 21;15°> all denote the same longitude. The notation is chosen to suit the context. It is assumed that William might designate this as "in the 22nd degree of Scorpio". -- In the few cases where decimals are used, I put the unit designation like this: "231°.25".

The symbols for Toledan tables, such as "PA21" or "EA41.Ear", refer to Pedersen 2002.

Medieval computational terms: My translations, as used in the Translation and the Appendix, can be seen in context in the Appendix, Rules for Calculation.

**Summary of the Canons:**

1: Preamble.

2-6: Motion of 8th sphere determined. Observation AD 1290 March 12, plus two observations at solstices, no date given.

7-10: Times of syzygies, correction -40m. Mean motion of Moon, correction +22' relative to Toulouse Tables.

11-15: Mean motions of Saturn and Jupiter, corrections +1;15° and -1°. Observations AD 1285 December 28-29 and (reported) 1226 March 4.

16-22: Mean motion of Mars, correction -3°. Observations AD 1290 March 3 and April 21, AD 1292 July 1-2, AD 1285 <July> 1.

23: Venus and Mercury, no corrections.

24-25: Mars, discussion of observations in AD 1290.

26-31: Explanation of the tables of the Almanach.

32-33: Epilogue 1: on astrological use of Almanach for times in the past.

34-39: Use of camera obscura for observing solar eclipses. Mentioning eclipse AD 1285 June 4.

40: Epilogue 2.

41-47: Auxiliary table for daily arcs, etc.

**References:**

Cb: Canons Cb to Toledan Tables, Pedersen 2002, vol. 2 p. 381-499.

Harper, R.I.: 1966, *The Kalendarium Regine of Guillaume de St-Cloud.* Diss. Emory Universiy, consulted in print from microfilm. -- p. 20-22, manuscripts for *Almanach* and tables, adding Cues 212, which is described as a "précis". -- p. 40-56, analysis of the *Almanach* canons, mainly a report of the contents, but identifying Beta Scorpii, cf. §16.

Mancha, J.L.: 1992, "Astronomical Use of Pinhole Images in William of Saint-Cloud's *Almanach Planetarum*", Archive for History of Exact Sciences 43, 275-298. -- p. 279-289, edition of the camera obscura passage (§§34-39 in this edition) with translation and commentary, and (p. 283) a summary of the observations described in the rest of the text.

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Toomer, G.J.: 1968, "A Survey of the Toledan Tables", *Osiris* 15, 5-174. Bruges.

Tuckerman, B.: 1964, *Planetary, Lunar, and Solar Positions A.D. 2 to A.D. 1649*. Memoirs of the American Philosophical Society, vol. 59. Philadelphia.

# Canons: Text

**Manuscripts used:**

**P:** Paris BN nal 1242, 41va-44vb, 14th c., no heading. Ends, ”Explicit hoc”. – Contains the text in the order presented here. – Scribal corrections are accepted tacitly unless noted.

**C:** Cues 215, 24va-31va, 13th-14th c., no heading. Ends, ”Explicit canon super almanach editus a magistro Guill(elm)o de Sancto Clodoaldo”. – Contains the text in the order presented here.

**N:** Paris BN lat. 7281, 141r-144v: ”Guill(elmu)s de sancto Clodoaldo Anno domini 1290”. No subscription. – Contains the text in the order presented here, except that §40 has been moved to the end of the text, after §46, and the table §47 has been omitted. – Shows many lesser word transpositions and explanatory supplements relative to PC, and more comprehensive re-phrasings in some places. A selection of larger variants are quoted.

**U:** Utrecht BRU 725 (s.XV), 201v-204r: ”Tractatus Petri de Padua de Motu 8’e sphere, compositione quoque Almanach per vigenos quosque annos, ac variis aliis astronomiam concernen(tibus).” No subscription. – The text is re-phrased in some passages and is heavily abridged near the end. Paragraphs 1-2, 5-27, and 37-40 can be collated with the rest of the manuscripts, and these passages seem to be of good quality. – There are a few marginal and interlinear glosses and computations, which have been ignored.

**Manuscript not used:** Cues 212, 15th c. -- Mentioned by Harper 1966 p. 21, where it is described as "... not a complete version of the text of the Almanach; it is a précis that ends after the discussion of the corrections for the medius motus of Mars".

**Text and editorial conventions:**

Generally I have followed P and/or C where supported by any of the others, if the reading makes sense.

P and C are much alike, though each has errors against the other. In a few places where C has omissions, P shows what may be private emendations (e.g. in §44). – N and U appear to revise the text of PC, and generally each in its own way; none of all these revisions seem to affect the sense or introduce new data, so I have chosen not to consider them as original. However, where N and U agree against PC, they often show a better text, which has been followed where necessary. Where U is absent, N alone also shows some readings that are necessary for emending senseless errors and omissions in PC.

A note is made if the adopted text rests on only one manuscript (or on none, in rare cases), or on two manuscripts against the consensus of two others, or on neither P nor C. However, I have tacitly followed C in trivial matters of conjunctions, particles, deictic pronouns, and notation of numbers and of ”gradus, minuta”. – In this way, no single manuscript can be reconstructed from the apparatus. On the other hand, the apparatus is only a third as bulky as the full one, and much less if this had included all the peculiarities of ms. N.

Details of spelling and punctuation are due to the editor. <Angular brackets> enclose passages that are in one manuscript only (typically N, see above), or are inserted by the editor. †Cruces† are used where the text I give is probably incorrect. In a few cases, [square brackets] are used for deletions by the editor, and [[double square brackets]] for deletions by the scribe.

**(PCNU:)** **{1}** Cum intentio mea sit componere almanach planetarum ad 20 annos, ex nunc – videlicet ab[1] anno domini 1292 – continue computandos, expedit in primis aliqua declarare, in quibus videbuntur loca planetarum ibi inventa a tabulis communibus discordare, ex quibus dari posset aliquibus occasio dubitandi, quibusdam vero materia detrahendi, illis maxime qui ob invidiam ad reprehendendum nova opera faciliter inclinantur.

**{2}** Primum igitur quod declarandum occurrit est quare ponam tantum tempore isto, scilicet anno domini 1292, motum 8'ae sphaerae, quem intelligo esse distantiam capitis arietis zodiaci mobilis, quem in 8'a sphaera imaginantur astronomi, ab intersectione eiusdem zodiaci cum aequinoctiali, ad quam quidem intersectionem sol veniens aequinoctium in omnibus climatibus operatur. Hanc enim distantiam pono temporibus istis 10 gradus et 15 minuta, cum tamen per tabulas Thebit de motu accessionis et recessionis 8'ae sphaerae non inveniatur esse huiusmodi distantia temporibus istis nisi 9 gradus et 23 m'a, ita quod fere in uno gradu a veritate discordat. **{3}** Quod autem tanta sit distantia huiusmodi [2]ut praedictum est, sic inveni: Sole existente in fine geminorum accepi altitudinem suam /C, 24vb/ in regione ista, videlicet Parisiensi, quam inveni esse[3] 64 gradus et 44 m'a, et vocatur altitudo principii cancri. [4]Item ipso existente in fine sagittarii accepi eius altitudinem, quam inveni 17 gradus et 36 m'a, et dicitur altitudo principii capricorni. Ex quibus duo notavi, scilicet maximam declinationem solis esse 23 gra et 34 m'a, quae habetur per subtractionem altitudinis solis existentis in fine sagittarii ab altitudine illius existentis in fine geminorum; medietas enim

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[1] PN; *om.* CU

[2] ut – inveni: u.p.e. \patet/ s. enim i. P; sic inveni C; uti p.e. sic inveni U; ut dixi sic inveni N

[3] PC; *om.* NU

[4] item – equinoctialis in meridiano (§4): PCN; altitudinem autem principii capricorni inveni 17 gra et 36 m'a. Subtracta minori a maiori residuatur amborum tropicorum distantia 47 gra et 8 minuta. Medietas huius est solis declinatio maxima, videlicet 23 gra et 34 minuta, que addita minori altitudini sive <a> maiori subtracta residuat sive producit ipsius equinoctialis altitudinem (super horizontem in meridiano) U

residui est maxima solis declinatio, quae est[1] iam posita. **{4}** Secundum autem quod per hoc habetur, est altitudo poli artici in regione ista. Si enim addatur maxima declinatio solis altitudini principii capricorni, vel subtrahatur ab altitudine principii cancri, habetur altitudo aequinoctialis in meridiano; [2]quae quidem aequipollet distantiae cenith capitum [3]<a polo artico, et est in ista regione 41 gra 10 m'a. Cum autem a cenith capitum> usque ad horizontem sint 90 gra, subtracta distantia cenith a polo, quae posita est, a 90 gradibus, remanebit distantia poli ab horizonte, et est 48 et 50 m’a.

**{5}** Istis notis ulterius sic processi. Anno domini 1290,[4] 12’a die Martii, quae fuit dies dominica qua cantatur Laetare Ierusalem, accepi altitudinem solis in meridie, quae fuit /C,25ra/ 40 gradus et 54 m’a. Et cum altitudo solis in meridie existentis in aequinoctiali in regione ista sit 41 gra et 10 m’a, /P,41vb/ qui excedunt praedictam altitudinem in 16

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[1] P, N(*aliter*); *om.* C; *alia* U

[2] quae -- 48°50’: *secutus sum* C, *supplemento ex* N *sumpto. Testes haec praebent:* que si subtrahatur ab 90 gra, remanebit distantia cenith ab equinoctiali, quia a cenith usque ad horizontem sunt 90 gra. Distantia autem cenith ab equinoctiali equipollet altitudini poli. Subtracta enim distantia cenith a polo a 4’a que est inter equinoctialem et polum, et a 4’a que est inter cenith et horizontem, que distantia cenith a polo est pars utriusque 4’e, remanebunt predicte distantie, scilicet cenith ab equinoctiali et poli ab horizonte, sibi invicem equales. Cum ergo subtracta fuerit altitudo equinoctialis in meridiano a 90, remanet distantia cenith ab equinoctiali, vel altitudo poli, cum sint equales, et est 48 gra et 50 m’a **P** ¶ que quidem equipollet distantie cenith capitum <**> usque ad orizontem sint 90 gra, subtracta distantia cenith a polo que posita est a 90 gradibus remanebit distantia poli ab orizonte et est 48 et 50 mi’a **C** ¶ scilicet capitis arietis et libre, que equipollet semper distantie cenith capitis regionis a polo artico, et est in ista regione 41 gra 10 m’a. Cum autem a cenith capitum regionis usque ad orizontem illius sint necessario 90 gra, substracta predicta distantia cenith regionis <a> polo artico, que posita est 41 gra 10 m’a, a 90 gra, remanebit altitudo poli illius ab orizonte regionis <..>s 48 gra 50 m’a **N** ¶ equalem distantie zenith capitum a polo arctico, videlicet grad() 41 et minut() 10. Cuius complementum quadrantis, scilicet 48 gra et 50 minuta, est distantia poli ab horizonte, equalis regionis latitudini seu distantie zenith ab equinoctiali **U**

[3] a polo – capitum: *ex* N, *q.v.s.*; *om.* C; *alia* P,U

[4] CNU; 1292 P

minutis, et sol quolibet die circa introitum suum in aequinoctialem addat altitudini suae 24 m'a fere, et hoc est in una hora unum minutum, sequitur quod [sol][1] per 16 horas post meridiem 12'ae diei Martii anno praedicto venit centrum corporis solis ad aequinoctialem. Et secundum ista motus 8'ae sphaerae fuit illo anno 10 gradus et 13 m'a. Aequando enim solem ad praedictam horam per tabulas factas ad 8'am sphaeram invenitur verus locus solis 11 signa 19 gra 47 m'a, quae subtracta de 12 signis ostendunt distantiam capitis[2] arietis mobilis ab aequinoctiali, scilicet 10 gra et 13 m'a.

**{6}** Ex istis concludi potest, ut videtur, vel quod motus 8'ae sphaerae, quem ponit Thebit, non habeat veritatem, vel quod diminutionem patiatur aliquam vel errorem. Et propter hoc rationabilius mihi videtur et securius /U,202r/ in motu isto magistros probationum imitari, qui in modo ponendi cum Ptolomaeo conveniunt, scilicet ponendo huiusmodi motum continue ab occidente in orientem secundum motum planetarum moveri, quamvis in quantitate cum eo non concordent, cum /C,25rb/ Ptolomaeus[3] in 100 annis per unum gradum huiusmodi motum ponat, magistri vero probationum, ut Alzophi et alii, in 70 annis per unum gradum; aliqui etiam in 66 annis per unum gradum asserunt ipsum esse, scilicet Albategni et eius sequaces. Cuius discordantiae causa est quantitas temporis inter observationes praedecessorum, quam habuerunt magistri probationum maiorem quam Ptolomaeus habuit, et ideo melius veritatem conicere potuerunt./N,141v/

**{7}** Secundum, quod postea expedit declarare, est quare a tempore mediarum coniunctionum et oppositionum solis et lunae subtraham 40 m'a horae. Ad quod sciendum quod hora verae oppositionis non semper est hora mediae eclipsis, ut ab aliquibus aestimatur, immo aliquando eam praecedit et aliquando eam sequitur, quandoque etiam est eadem. Quando enim luna accedit ad nodum, sive ad caput sive ad caudam,

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[1] PCU, N *a.c.*
[2] NU; *om.* PC
[3] cum pt.: PC; pt. namque U (*sed coniunctivum* "...ponat" *retinet*); pt. enim N (...ponit)

tunc hora verae oppositionis praecedit horam mediae eclipsis; quando vero a nodo recedit, e converso est, scilicet quod hora mediae eclipsis praecedit horam verae oppositionis; quando autem contingit lunam esse in nodo hora mediae eclipsis, tunc eadem est hora verae oppositionis et hora[1] mediae eclipsis. Hoc enim faciliter apparere potest cuilibet consideranti modum intrandi et exeundi lunae in /C,25va/ umbram; et hoc quidem contingit eo quod centrum umbrae semper est in ecliptica sive in via solis, centrum autem lunae non, et quanto est remotior luna[2] a nodo in medio eclipsis, tanto est maior diversitas in tempore inter horam mediae eclipsis et horam verae oppositionis. Ista tamen diversitas sive antecedendo sive[3] subsequendo non excedit 10 m'a horae vel 12. **{8}** Unde si tabulae eclipsium verae essent cum praecisione, inveniretur tamen ex hac causa aliqua vera oppositio aequata /P,42ra/ per eas praecedere suam mediam eclipsim, et alia aliqua[4] inveniretur sequi, aliqua etiam quae simul esset. Nunc autem non est ita, immo per multas eclipses[5] probatum est temporibus istis semper horam mediae eclipsis praecedere veram oppositionem aequatam per tabulas, quae tamen, sicut dictum est, si verae essent tabulae, aliquando praecederet, aliquando sequeretur, aliquando etiam simul esset.[6] Inventa est enim[7] aliqua eclipsis quae praecessit[8] veram oppositionem aequatam per tabulas plus quam per unam horam; aliqua vero inventa est quae tantum praecessit per 20 m'a; quaedam etiam per 45; quaedam per 30 m'a; et secundum plures alias diversitates infra horam unam et supra 20 m'a, de quibus exempla possem ponere, /C,25vb/ quia eas observavi, nisi taedium et prolixitas interesset. **{9}** Nulla enim, ut credo, temporibus istis videtur eclipsis quae non praecedat suam veram oppositionem ad minus per 20 m'a horae; ex quibus sequi videtur errorem aliquem esse,

[1] PC; *om.* NU
[2] e.r.l. : CU; l.e.r. P; r.e.l. N
[3] in *add.* CU
[4] a.a.: CU; aliqua alia N; aliqua et alia P
[5] particulares et (+etiam per U) aliquas universales *add.* NU
[6] e.s.e.: C; similis e. P; si(mu)l e. N; etiam e. simul U
[7] per me *add.* N
[8] q.p.: NU; ante P (*manu altera ut vid.*); *om.* C

non solum in medio motu lunae, [1]sed etiam in argumento ipsius lunae. Suppono enim aequationem solis veram esse. Ex hoc enim quod semper praecedit medium eclipsis suam veram oppositionem aequatam per tabulas, sequitur quod error sit in medio motu. Si enim tantum esset error in argumento, ex illo sequeretur aliquando medium eclipsis praecedere veram oppositionem aequatam per tabulas et aliquando sequi, quod non contingit. Ex hoc autem quod non semper uniformiter praecedit, sed aliquando plus et aliquando minus, sequitur defectum esse in argumento. Non enim praedicta causa, [2]<scilicet> de diversitate intrandi in umbram vel exeundi, sufficit ad salvandum dictam diversitatem, quia non excedit 10 m'a horae vel 12, ut dictum est; potest tamen esse pars <illius>.[3] **{10}** Propter hoc ergo subtraxi a tempore mediarum coniunctionum et oppositionum 40 m'a horae, quia medio loco se habent inter horam unam et 20 minuta horae, pro correctione /U,202v/ medii motus lunae. Quantum enim ratione argumenti deficiat, non adhuc probavi; illud tamen /C,26ra/ minus est quam illud in quo est defectus ratione medii motus. Quibus 40 minutis correspondent 22 m'a tantum de medio motu lunae, in quibus videtur minus habere tabula medii motus lunae in annis collectis in temporibus istis quam debet.[4] Quod quidem accidere potuit pro eo quod in motu diurno lunae tabulae deficiunt in aliquibus secundis vel tertiis, quae a tempore compositionis tabularum [5]aggregata, licet in principio compositionis tabularum errorem sensibilem non facerent, modo tamen aggregata aliqua minuta constituunt quae errorem sensibilem inducunt.

**{11}** [6]De Saturno vero et Iove simul probavi /N,142r/ quod sequitur ad oculum. Anno domini 1285 imperfecto, die Veneris post Natale, post

[1] sed – ipsius lunae (i.l.: eius N): NU; *om.* PC

[2] s(cilicet) de: U; de CN; ex P

[3]illius: cause illius N; [[pa(r)s]] P (*dittogr.*); *om.* CU

[4] PC; debeat U; debeat habere N

[5] aggr. – comp. tabularum (c.t.: earum N): NU; om. PC

[6] de Saturno vero: C; de Saturno P; de Saturno autem U; 3'm quod restat declarandum est quare addam ad medium motum Saturni inventum per tabulas Tholose 1 gra 15 m'a, et substraham a medio Iovis 1 gra, et substraham

occasum solis, vidi Saturnum et Iovem, et erat adhuc /P,42rb/ Iupiter retro Saturnum quasi per dimidium gradum. Similiter die sabbati sequenti vidi eos, et modicum minus distabant quam prius, ita quod secundum aestimationem videbatur quod coniungi deberent ultima die Decembris, scilicet die lunae post, et non ante, quamvis secundum tabulas Tolosanas Iupiter iam transivisset eum plus quam per duos gradus; ita quod per eas inveniebantur coniuncti plus quam [1]per 15 dies antequam realiter coniuncti fuerunt. Similiter etiam per tabulas Toletanas; et adhuc maior invenitur diversitas per eas quam per Tolosanas. /C,26rb/ **{12}** Unde secundum istam observationem videtur quod error sit in medio motu, vel utriusque vel alterius. Magis tamen verisimile videtur quod sit error in utroque, licet maior sit in Saturno, ita quod medius motus Iovis, ut credo, maior est per tabulas quam esse debeat in annis collectis fere in uno gradu, Saturni vero minor in uno gradu et 15 minutis vel circiter. Sic enim aequando ipsos, scilicet per subtractionem unius gradus fere a medio motu Iovis et per additionem unius gradus et 15 minutorum vel circiter ad medium motum Saturni inventum per tabulas Tolosae, invenientur coniuncti praedicta die, in qua secundum apparentiam coniuncti fuerunt.

**{13}** Huic etiam observationi concordat observatio facta per 60 annos ante istam. Inveni enim in quodam libro in margine eam scriptam sic: "Anno domini 1226 imperfecto, quarta die Martii, scilicet die Cinerum, circa auroram, fuit visa coniunctio Saturni et Iovis, et cuidam revelatum[2] fuit[3] per visionem." Hucusque verba inventa; ex quibus suppono Saturnum et Iovem hora quae ibi scribitur fuisse vel coniunctos vel prope coniunctionem. Fuit enim in eisdem partibus caeli, in quibus et praedicta fuit, scilicet in principio aquarii, in quo loco Saturnus et Iupiter fere /C, 26va/ eandem habent latitudinem,[4] maxime quando sunt directi,

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a medio Martis 3 gra, in Venere et Mercurio nihil addam vel substraham. Pro quo sciendum est quod de Saturno N

[1] per 15 dies ant.: NU; *om.* PC

[2] PCU; ostensa et revelata N

[3] PU; *om.* CN

[4] CNU; alt- P

sicut fuerunt in utraque istarum observationum, [1]ita quod ratione latitudinis[2] non debuit esse error in alterutra harum[3] observationum. Potuit enim[4] in utraque satis prope haberi locus et tempus coniunctionis istorum planetarum absque errore notabili, absque instrumento. **{14}** Nunc autem aequando eos per tabulas Tolosae ad dictam horam, scilicet quarta die Martii circa auroram anno[5] domini 1226, invenitur quod iam transierat Iupiter Saturnum plus quam per unum gradum et dimidium; aequando vero eos per modum praedictum pro correctione ipsorum, invenietur adhuc Iupiter retro Saturnum fere per tertiam partem gradus, ita quod, quamvis praecise non concordet haec observatio cum priori, propinquius tamen multo accedit quam tabulae. Potuit tamen in utraque observatione modicus error accidere, qui forte compositus causat istam discordantiam. – **{15}** Propter ista motus fui in aequando istos duos planetas pro almanach faciendo non imitari tabulas, sed per modum praedictum ipsos aequare. Non tamen hoc adhuc assero ita esse; forsitan enim in motu istorum aliquid mihi /P,42va/ latet quod per observationes per instrumentum manifestari poterit in posterum. Quicumque tamen istud voluerit[6] imitari, potest faciliter aequationes eorum ad aequationes /C,26vb/ tabularum reducere, /U,203r/ scilicet per additionem unius gradus fere vero[7] loco Iovis et per subtractionem unius gradus et 15 minutorum vel circiter a vero loco Saturni. Quod enim correspondet uni gradui de aequatione centri et similiter de aequatione argumenti in istis duobus planetis, non est notabile.

**{16}** De Marte autem, qui ceteris †celerior†[8] invenitur, nunc dicendum. Suppono igitur per observationes quas feci ad oculum, Martem fuisse coniunctum cum stella una quae est in ungula septentrionali scorpionis,

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[1] ita quod – observationum: NU; *om.* PC
[2] NU; *def.* PC
[3] a.h.: U; aliqua istarum N; *def.* PC
[4] potuit enim: CU; potuit P; et potuit N
[5] NU; anni PC
[6] uolu(er)it PC; volu(er)it U; nolu(er)it N *ut vid.*
[7] vero ... vero: PCNU; potius medio U (*una glosa ad utrumque locum adiecta*)
[8] cet.cel.: U; [[centrum]] \cet./ differentior N; in cet. deterior PC

circa 21[1] gradum scorpionis, nocte sequente diem Veneris quae fuit tertia dies Martii anno domini 1290, ipso adhuc existente directo, et ipsum eam transivisse usque ad stationem suam primam circiter per tres gradus, et postea per retrogradationem rediisse ad eandem stellam nocte sequente 21 diem Aprilis; et quod prima vice fuit Mars septentrionalis ab illa modicum quasi per 12 m'a vel circiter, et secunda vice fuit meridianus, ab eadem distans in latitudine[2] versus meridiem fere in triplo tantum quantum distabat prima vice ab ea versus septentrionem. **{17}** Posui igitur pro radice in correctione motus ipsius Martis medium motum solis in duabus observationibus /C, 27ra/ praedictis; et variavi medium Martis, quousque haberem talem medium motum eius ad /N,142v/ utramque observationem, quod per eum et per argumentum ipsius – factum per subtractionem medii motus Martis a medio motu solis immobili permanente – proveniret locus unus et idem, sicut fuit in dictis observationibus. Et inveni quod ad hoc habendum oportet a medio motu ipsius per tabulas Tolosanas[3] invento subtrahere tres gradus completos vel fere. Isti autem tres gradus erroris in medio motu tantundem erroris faciunt in centro; similiter et in argumento, sed tamen converso modo, quia cum per eos minuantur medius motus et centrum, augetur argumentum.[4] **{18}** Faciunt autem praedicti tres gradus in aequatione ipsius Martis errorem in diversis partibus caeli diversimode, ita quod, quando centrum epicycli est in auge [5]excentrici, et corpus ipsius Martis est in auge epicycli, tunc accidit minor error qui possit accidere ratione praedictorum trium graduum; tunc enim aequando ipsum per tabulas non invenitur error nisi in uno gradu et 32 minutis, eo quod error, qui accidit in medio motu ipsius, tunc minuitur per errorem qui accidit in aequatione centri et aequatione argumenti. **{19}** Quando vero centrum epicycli fuerit in opposito augis [6]excentrici et corpus

[1] PCNU
[2] PCU; *def.* N
[3] CU; tholosas P; tholose N
[4] aug. argumentum: P; arg.aug. U; aug. et arg. N; aug. C
[5] excentrici – ipsius (ipsius *om.* N) -- in auge: NU; *om.* C; deferentis et cum hoc centrum corporis ipsius Martis est in auge P
[6] excentrici -- in opposito augis: NU; *om.* C; deferentis et corpus ipsius Martis in opposito augis P

Martis in opposito augis epicycli, tunc accidit maior error /C,27rb/ qui possit accidere ratione praedictorum trium graduum. Tunc enim aequando ipsum per tabulas inveniuntur errare in 13 gradibus et 34 minutis: tunc enim illis tribus /P,42vb/ gradibus correspondent de aequatione centri 40 m'a. Ipsis vero tribus gradibus et 40 minutis, quae eis addi debent aequando argumentum, correspondent de aequatione argumenti 7 gradus, et de diversitate diametri, quae tunc est longitudo propior,[1] correspondent duo gradus et 54 m'a. Quae omnia aggregata cum illis tribus gradibus faciunt 13 gradus et 34 m'a, in quibus reperitur locus Martis maior per tabulas quam sit realiter, ratione praedictorum trium graduum. In locis vero intermediis accidit error medio modo.

**{20}** Et hoc quidem quod nunc dictum est probavi, ipso existente retrogrado in capricorno, anno domini 1292, nocte sequente primam diem Iulii, quae fuit dies Martis ante festum beati Martini aestivalis. Tunc enim in media nocte recte vidi lunam cum Marte, et inspiciendo per armillas videbatur luna transivisse eum quasi per unum gradum. Aequando autem lunam ad horam praedictam per tabulas Tolosae, addito motu 8'ae sphaerae, invenitur in 26 gradu /C,27va/ capricorni; aequando vero Martem ad eandem horam per easdem tabulas, addito similiter motu 8'ae sphaerae, invenitur in 7[2] gradu aquarii; ita quod inveniuntur tabulae errare plus quam in 11 gradibus; non enim erant[3] in loco in quo maximus defectus debet accidere. Si autem /U,203v/ aequetur per modum supradictum, scilicet subtrahendo 3 gradus a medio motu eius in principio operis et postea procedendo per eum secundum doctrinam canonum, invenietur ad horam praedictam in 25 gradu capricorni, prout per dictam observationem repertum fuit, scilicet minus uno gradu quam luna; [4]ita quod ista observatio praedictam confirmat. – Plures etiam alias observationes feci cum luna et etiam cum

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[1] l.p.: PC; longi(tu)d(inis) propior(is) U (*ut vid.*); in longitudine propiori N
[2] C; 7° PNU
[3] enim erant: PCU; tamen adhuc erat Mars N
[4] ita – confirmat (-met P) : PCU; et forte in luna est aliquis defectus ut prius dixi in medio motu eius qui posset facere errorem de 1 gra in vero loco; sic ista obs. praed. confirmat N, *prave*

aliis, per quas idem confirmari posset nisi taedium interesset; sufficiant igitur quoad nunc praedicta.

**{21}** Quod autem aliquando non faciant illi tres gradus erroris nisi unum gradum et 32 m'a vel circiter in aequatione ipsius Martis, probavi [1]anno domini 1285 prima die †Iunii† ante ortum solis sub altitudine Aldebaran 12 graduum. Vidi enim tunc lunam cum Marte. Poterit etiam idem experiri anno domini 1293 in Maio vel Iunio, si videri possit: tunc enim erit centrum epicycli prope /C,27vb/ augem excentrici et corpus eius prope augem epicycli. **{22}** Consideret igitur ex praedictis quilibet, qui penitus tabulas imitatur, quam turpiter possit errare in iudiciis quibuscumque. Non enim est[2] mirum si eas imitando in iudiciis sint decepti, cum coniunctiones et applicationes et separationes planetarum adinvicem, nec non et directiones, multo[3] diversae sint secundum veritatem ab his quae per tabulas habentur, [4]ut potest cuilibet per praedicta faciliter apparere.

**{23}** De Venere autem et Mercurio correctionem nullam hic pono; quamvis enim de ipsis observationes plures fecerim, sicut de aliis, per ipsas tamen aut nullum aut modicum errorem in eorum motu potui perpendere. /P,43ra/ Suppono enim[5] de ipsis, sicut de sole et luna, quod propter velocitatem motus eorum [6]frequentius et melius potuit eorum motus corrigi quam aliorum, quia etiam[7] medius motus eorum /N,143r/ idem est cum medio motu solis; et ideo credo quod loca ipsorum[8] verius inveniantur per tabulas quam aliorum.

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[1] anno -- graduum: anno domini 1285 prima (*om.* P) die iunii ante ortum solis (s.o. N) sub altitudine (+stelle N) aldebaran 12 graduum (g(ra) PN) PCNU
[2] CU; *om.* PN
[3] PC; in plurimo U; multum N
[4] ut potest – apparere: CN; ut cuilibet studiose ingenium suum huiusmodi rebus applicanti facile per praedicta potest apparere U; \sicut/ per predicta cuilibet apparere faciliter \potest/ P
[5] PCNU
[6] frequentius – motus: NU; *om.* PC
[7] q.e.: U; e. N; q. et P; q. est(!) C
[8] PC; eorum NU

**{24}** De Marte tamen multum est mirandum quod tantus error in motu ipsius usque ad ista tempora remansit, nisi pro tanto quod raro accidit, ipso existente retrogrado, eum transire prope /C, 28ra/ aliquam stellam fixam bis, semel procedendo et postea retrocedendo, sicut fuit in utraque praedicta observatione. Transivit etiam in utraque prope illam stellam quantum ad latitudinem,[1] ita quod absque errore notabili potuit iudicari tempus coniunctionis eius cum ea absque instrumento. Transivit etiam in coniunctione prima supra dictam stellam et in secunda sub,[2] quasi describendo talem lineam per transitum suum:

**(PC(N):)** **(1)**[3] Transitus Martis super stellam – **(2)** Stella quae est[4] in ungula septentrionali scorpionis – **(3)** Statio Martis prima[5] – **(4)** Transitus Martis sub stella per retrogradationem[6] – **(5)** Statio Martis secunda[7]– **(6)** Mars directus post stationem secundam – **(7)** Ungula meridiana scorpionis – **(8)** Cor scorpii[8]

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------------------(1)------------------
|
|                  (2)
(3)
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|
------------------(4)------------------
                                      |
                                      |
                                     (5)
                                      |
                                      |
------------------(6)------------------

          (8)           (7)
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[1] NU; alti- PC
[2] ea *add.* N
[3] (1)-(8): PC; Mars directus; Statio <->; Stella ungule scorp() 7'lis: Retrogradus; Statio <->; Directus N, fere; *figuram omittit* U. – *Numeri ab editore inserti sunt, quo facilius figura exprimeretur.*
[4] C; *om.* P
[5] s.m.p.: C; mars stationarius statione prima P
[6] C; -du(m) P
[7] s.m.s.: C; mars stationarius statione secunda P
[8] P; scorp() C

**(PCNU:)** **{25}** Raro enim accidit quod talem transitum circa stellam fixam faciat, vel etiam circa planetam tardum, et si forte quandoque acciderit, non tamen fuit qui consideraret; vel si fuit, ad nos tamen nondum pervenit. Multae enim tales observationes transeunt, per quas possent[1] motus aliquorum planetarum corrigi, quae tamen ab aliquo non notantur; credo etiam quod a longo tempore non fuerunt factae observationes per instrumenta, per quas corrigerentur loca planetarum vel etiam stellarum fixarum. Spero autem quod in proximo cum adiutorio dei /C,28rb/ fiet instrumentum per quod huiusmodi loca corrigi poterunt; spero etiam quod correctiones factae per ipsum a praedictis[2] correctionibus factis ad oculum nihil vel modicum deviabunt.

**{26}** Sciendum est praeterea quod, in toto almanach, sol et quinque planetae alii a luna aequati sunt ad meridiem diei, in directo cuius[3] ponuntur loca ipsorum in nona sphaera, ita /P,43rb/ quod secundum modum astronomorum incipit dies in meridie diei praecedentis et terminatur in meridie sui.[4] – Sol quidem aequatus est ad singulos dies in gradibus et minutis. – Tres vero superiores, scilicet Saturnus Iupiter et Mars, aequati sunt in gradibus et minutis de 10 in 10[5] dies, in diebus vero intermediis in gradibus tantum, acceptis secundum proportionem unius aequationis ad sequentem. – Venus vero et Mercurius aequati sunt[6] de 5 in 5 dies in gradibus et minutis, et in diebus intermediis in gradibus tantum, acceptis /C,28va/ secundum proportionem unius aequationis ad sequentem. /U,204r/ – Luna semper aequata est, [7]non ad meridiem, sed ad horam mediae coniunctionis vel oppositionis in nona sphaera; et in 14 diebus, qui sunt inter mediam coniunctionem et mediam oppositionem, aequata est ad similem horam horae mediae coniunctionis vel oppositionis praecedentis. **{27}** Et ideo in margine

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[1] PC; posset NU
[2] meis *add.* U; *def.* N
[3] d.c.: PC; c.d. NU
[4] PU; sua CN
[5] de 10 in 10: PC; ad 10 N; per 10 et 10 U
[6] aeq. s.: N; aeq. CU; s. aeq. P p.c.: e(st) aeq. P *a.c. ut vid.*
[7] non – sed: PCU; ad singulos dies N

inferiori posui in quolibet mense tempus mediae coniunctionis et tempus mediae oppositionis illius mensis, ut sciatur hora ad quam aequata est luna. Accidit autem aliquando quod aequatio ultimae diei illorum 14 et aequatio coniunctionis vel oppositionis sequentis cadunt inter duas meridies, et ideo oportet unam illarum aequationum ponere extra; rationabilius autem est[1] quod aequatio ultimae diei extra ponatur, [2]et ideo eam posui extra. **{28}** Posui etiam in directo cuiuslibet mediae coniunctionis et oppositionis medium motum lunae in 8'a sphaera ad horam illius mediae coniunctionis vel oppositionis. Et per eum haberi potest medius[3] solis, [4]quia in coniunctione idem est medius motus lunae et solis; in oppositione vero habetur[5] medius solis per additionem 6 signorum ad medium lunae. Et si velimus eum habere in nona sphaera, addatur /C, 28vb/ ei motus 8'ae sphaerae, qui ponitur in Martio in quolibet anno. – Posui etiam argumentum lunae ad easdem horas, scilicet mediae coniunctionis et oppositionis, ut per eum[6] sciatur in quo loco sit luna in suo[7] epicyclo, et per hoc, utrum sit velox vel tarda cursu. – Posui insuper buth solis et buth[8] lunae, id est motum aequatum in una hora; **(PCN:)** [9]solis quidem, ut per eum habeatur verus locus solis ad horam mediae coniunctionis vel oppositionis, multiplicando ipsum per horas quae sunt post meridiem usque ad horam mediae coniunctionis

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[1] r.a.e.: C; r.e.a. P; r. tamen e. U; et r.e. N

[2] et – extra: PC; prout feci NU

[3] h.p.me.: U; p.h.me. motus P; h.p. motus me. C; (ut…) h. possit me. N

[4] quia (scilicet C) – quolibet anno: PC, N *fere*; qui idem est in coniunctione media, sed in oppositione oportet addi 6 signa, et si addatur ei motus 8'e spere positus semper in Martio cuiuslibet anni, emerget motus in 9'a spera U

[5] v.h.: C, P *p.c.*; h.v. P *a.c.*; media h. N; *alia* U

[6] per eum(!): PCN; *om.* U

[7] PC; *om.* NU

[8] PC; *om.* NU

[9] solis -- duas tabulas longioris longitudinis et propioris: PCN; ad practicandum verum locum et tempus vere coniunctionis et oppositionis iuxta canones communes, per quem modum et canones etiam practicari possent eclipses luminaris utriusque etc(etera) U

vel oppositionis, et quod inde provenit addendo vero loco solis ad illam meridiem.[1]

**{29}** Buth autem lunae posui ut, habito vero loco solis ad horam mediae coniunctionis vel oppositionis ut praeostensum est, et vero loco lunae ad eandem horam, qui scriptus est in almanach, haberi possit faciliter tempus verae coniunctionis vel oppositionis. Si enim accipiatur differentia inter verum locum solis et lunae in media coniunctione vel oppositione, et ei addatur sua 12'a, et aggregatum dividatur per buth lunae in hora correspondente illi mediae coniunctioni vel[2] oppositioni, exibit tempus quod est inter mediam coniunctionem vel[3] oppositionem et veram. Quod si sol lunam praecedat, addatur hoc tempus tempori mediae coniunctionis vel oppositionis, /C,29ra; N,143v/ et habebitur tempus verae coniunctionis vel oppositionis ad dies medios; si vero /P,43va/ luna praecedat, minuatur illud tempus. Postea quaeratur aequatio dierum et addatur illi tempori; et habebitur tempus verae coniunctionis vel oppositionis ad dies aequatos. – **{30}** Et ex hoc etiam faciliter haberi potest quando erit eclipsis lunae, quia, habita vera oppositione, videndum est si sit de nocte, comparando horas verae oppositionis [4]<ad medietatem horarum diei illius; et si plus distat hora verae oppositionis> a meridie praecedenti vel subsequenti[5] quam [6]sit medietas horarum diei artificialis, nocturna erit. [7]Et si tunc sol et luna minus distent a capite vel cauda draconis [8]quam per 12 gra,[9] haberi poterit quantitas eclipsis satis prope, proportionando cum argumento latitudinis[10] lunae duas tabulas longitudinis longioris et propioris.

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[1] ad illam m.: C; ad illum m. P; in illa meridie N
[2] N; et PC
[3] N; et P; sive C
[4] ad med. – oppositionis: N; *om.* PC
[5] PC; sequenti N; quia si fuerint plures add. P
[6] sit – noct. erit: CN; sint hore medietatis illius diei artificialis erit de nocte P
[7] et si (sic C) – distent: C; et si tunc luna minus distet P; si minus, diurna erit. Et cum fuerit nocturna, si sol et luna tunc minus distent N
[8] q.p. 12 g.: P; 12 gradibus N; om. C
[9] ante vel retro, eclipsabitur tunc luna, et per distantiam illam lune a capite vel cauda *add.* N
[10] PN; *om.* C (*cf. canones tabularum Toletanarum* Cb200-201a)

**(PCNU:)** Nihilominus tamen intendo per totum almanach notare tempora[1] et quantitates eclipsium tam solis quam lunae.

**{31}** Posui etiam in almanach de novo[2] latitudinem lunae ad singulos dies [3]ad similem horam ad quam aequata est luna, et signavi quando est septentrionalis vel meridiana, descendens vel ascendens.[4] **(PCN:)** [5]Hoc enim perutile et necessarium[6] in iudiciis reperitur.

**{32}** Quantum vero profecerim, quotque labores redemerim in compositione huius operis professoribus[7] nobilissimae scientiae astronomiae iudicativae, cuilibet potest, qui in ea mentem apposuerit, /C,29rb/ faciliter apparere. Habent enim usque ad 20 annos illam nobilem atque mirabilem choream planetarum, quam Plato in Timaeo a paucis cognitam esse dicit. Quantum autem laboraverim, quot etiam[8] expensas fecerim pro ipso componendo, nullus nisi qui in opere mecum[9] interfuerit poterit iudicare.

**{33}** Nec est opinandum, ut aliqui credunt, quod, transacto tempore[10] in toto vel in parte ipsius almanach, quod illud quod praeteritum erit sit inutile et de eo non curandum; immo aeque et praeteritum et futurum servandum est sicut praesens. Non enim in scienda condicione alicuius rei praesentis vel futurae solum dispositio caelestis praesens vel futura est consideranda, sed etiam cum hoc praeterita; non enim in sciendis accidentibus alicuius anni nati[11] sola dispositio caeli in revolutione illius

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[1] NU; tempus P; *om.* C
[2] d.n.: CN; *ante* in alm. U; *om.* P
[3] ad – ascendens: PCN *fere*; 7'l(em) vel austral(em), ascenden(tem) vel descenden(tem) etc(etera) U
[4] d.v.a.: P; a. C; a. et d. N; *alia* U
[5] hoc enim – per plures alios auctores (§33): *habent* PCN; *om.* U
[6] e.n.: C; *post* reperitur P; (...quia hoc necessarium et perutile in iudiciis astronomie reperitur N)
[7] =N; in *add.* PC
[8] quot etiam: C; quotque N; quantasque P
[9] C; *ante* in opere N; *om.* P
[10] PN; *om.* C; illo *add.* N
[11] al.an.n.: PC; alicuius nati in aliquo anno N

anni est videnda, sed etiam dispositio caeli in hora nativitatis, quae praeterita est, et unius ad alteram collatio facienda. Similiter et in revolutionibus annorum mundi; non enim sufficit in eis [1]aspicere coniunctionem praecedentem ipsam revolutionem, sed oportet recurrere ad coniunctionem praecedentem coniunctionem minorem Saturni et Iovis proximo praeteritam, ut apparet per Ptolomaeum, 65 propositione Centilogii. [2][Hoc etiam idem[3] oportet in /C, 29va/ quaestionibus, de quibus tamen minus[4] <**> videretur si secure et perfecte quis voluerit iudicare, ut apparet] per Haly exponentem praedictam[5] propositionem et etiam per plures alios auctores.

**(PCN:)** **{34}** [6]Quia vero intendo loca et tempora et etiam quantitates eclipsium tam solis quam lunae notare in almanach, eclipsium autem solarium nulla, nisi medietatem excedat, /P,43vb/ potest ad oculum observari nisi contingat eam esse circa ortum vel occasum solis, ita quod propter oppositionem[7] vaporum lumen solis debilitetur, quod tamen raro contingit – ideo intendo hic experimentum quoddam ponere, per quod poterit quaelibet eclipsis ipsius solis quantumcumque parva notari, etiamsi solum medietas puncti deficeret, ne forte, si propter defectum visus aliqua talis eclipsis in almanach posita videri non posset, imputaretur errori, **{35}** ne etiam ipsas eclipses observantibus contingat illud quod pluribus accidit anno domini 1285 quarta die Iunii, scilicet

[1] aspicere – apparet: *scripsi e.g.;* aspicere ad coniunctionem vel preventionem precedentem ipsam revolutionem, sed oportet recurrere ad coniunctionem vel preventionem precedentem coniunctionem minorem (c.m.: minorem const()m P) Saturni et Iovis proximo preterite, ut apparet PC; aspicere coniunctionem presentem precedentem revolutionem, sed oportet considerare ad coniunctionem minorem saturni et iovis proximo preteritam, ut apparet N

[2] hoc – apparet: PC; et N

[3] C; i(llu)d P; *def.* N

[4] C; mi(us) *vel* mi()i P; *def.* N

[5] PC; i(ll)am N

[6] quia -- alibi locum habent (§37): PCN; ut autem eclipsis solis quamlibet parva visu notari illeso possit, fiat vas profundum repletum aqua clara in loco quieto, vel quod commodius et penitus absque visus impedimento est U

[7] PC; interp- N

quod propter fortem intuitum solis per parvam quantitatem eclipsis accidit illis, qui sic solem fortiter inspexerant, quaedam in oculis tenebrositas quae communiter accidit intrantibus umbram postquam fuerint in claritate solis; quae quidem tenebrositas in quibusdam remansit /C,29vb/ per duos dies, in aliis per tres, in aliis etiam per plures, secundum quod intensius et diutius solem inspexerant, et forte etiam[1] secundum quod plus vel minus apti erant eorum oculi ad huiusmodi tenebrositatem. Unde videtur quod in tantum posset aliquis solem aspicere quod penitus excaecaretur, iuxta illud dictum Philosophi: Excellentiae sensibilium corrumpunt sensum. Causa autem illius accidentis alibi declaratur. **{36}** Solent autem aliqui eclipsim in aqua posita in pelvi aspicere; sed illud non sufficit, /N,144r/ quia ab aqua reflectitur lumen solis, licet debilius sit lumen reflexum quam lumen proprium; ita etiam praedictum accidens induceret, licet debilius. Si sic[2] tamen fiat, proprie debet fieri in aqua clara et vase profundo existente in loco quieto.

**{37}** Ut igitur praedictum accidens penitus evitetur, experimentum aliud[3] explanetur, per quod non solum eclipsis solis absque laesione oculorum poterit observari, sed etiam hora initii eius et finis, nec non et quantitas punctaliter[4] mensurari, et etiam quaedam alia quae alibi locum habent. **(PCNU:)** [5]Fiat igitur in domo clausa foramen in tecto vel fenestra versus partem illam in qua debet eclipsis solis evenire; sit autem quantitas foraminis sicut /C, 30ra/ est foramen a quo extrahitur vinum a doliis. Lumine igitur solis per huiusmodi foramen intrante, ad distantiam foraminis 20 pedum vel 30[6] aptetur res aliqua plana utpote asser unus, ita quod huiusmodi lumen solis super illius rei superficiem perpendiculariter cadat. Videbitur autem lumen in suo casu super huiusmodi superficiem penitus rotundum, etiamsi foramen angulare

[1] f. etiam: C; f. P; *om.* N
[2] si sic: P; si N; sic *vel* sit C
[3] e.a.: C; aliud P; experimentum N
[4] PC; punctorum N
[5] fiat – doliis: PC, N *fere*; fiat foramen in tecto domus clause ad quantitatem foraminis dolii, sive in aliqua fenestra, versus partem illam in qua eclypsis evenire debet U
[6] p.v.30: PC; v.30 p. NU

esset; erit etiam maius foramine, [1]et quanto magis distabit huiusmodi res plana a foramine, tanto lumen super ipsam cadens latius apparebit, erit tamen debilius quam[2] prope. **{38}** Et si a centro foraminis, si parvum fuerit foramen – vel a concursu extimorum[3] radiorum solis ultra foramen, si magnum fuerit – usque ad casum luminis describatur unus circulus, ita quod centrum huius[4] circuli sit centrum foraminis vel concursus extimorum[5] radiorum, et circumferentia /P,44r/ eius transeat per ipsum casum luminis, invenietur lumen in loco casus proportionaliter abscindere[6] de circulo secundum proportionem diametri solis in caelo, ita quod, [7]si diameter solis fuerit[8] 30 m'a in caelo, diameter etiam luminis abscindet 30 m'a de circulo; si vero plus fuerit, plus abscindet. – Unde per hoc videtur [9]posse probari excentricitas solis ad oculum, supposito quod rationabilius sit ipsum habere excentricum

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[1] et – prope: PCN; ipsum lumen super rem cadens, quanto(m)agis ipsa res plana a foramine distiterit \et latius/, debilius tamen erit quam si minus elongata fuerit U

[2] si *add.* N; *alia* U

[3] extimorum: N; ext(ra)im- P; extremorum CU (*sed cf. infra*)

[4] NU; h(uiusmod)i PC

[5] extimorum: CN; ext(ra)imorum P; ext(r)emorum U

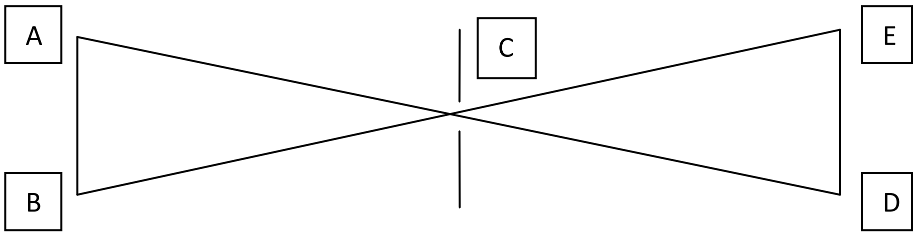
[6] NU; abscon- P; an(te) abscidere C

[7] si – caelo: *om.* C

[8] NU; abscindat P; *def.* C

[9] posse – in ipso foramine (§39): PCN; probari posse distantia solis a terra et ecentricitas eius ad oculum, supposito tamen quod habeat ecentricum, quod rationabilius astronomis visum est quam epicyclum, cum alterutrum sit necessarium secundum eos. Cum enim sol in auge ecentrici fuerit, tunc remotior erit a terra quam in augis existens opposito; hinc minor apparere debet in auge, lumenque cadens per foramen super planum huiusmodi erit minus. – Hiis itaque hora oportuna dispositis, tempore eclypsis observetur lumen cadens super planum; et incipiente eclypsi, videbitur illud lumen proportionaliter deficere secundum defectum in sole, augmentabiturque atque decrescet secundum ipsius augmentum et diminutionem, differentia saltem in hoc apparente quod pars luminis deficiens opposita erit parti solis deficienti, pars videlicet solis orientalis deficiens parti luminis occidentali et e converso. Et hoc est propter intersectionem radiorum in ipso foramine, causantem radiorum penetrantium alternationem U

quam epicyclum, cum oporteat alterum. Cum enim sol in auge existens remotior sit /C,30rb/ a terra quam quando fuerit in opposito augis, minor debet apparere, similiter etiam et lumen huiusmodi cadens per foramen super planum huiusmodi minus erit. – **{39}** Hiis ita dispositis, hora qua debet esse eclipsis observetur illud lumen cadens super planum; et quando eclipsis incipiet, videbitur illud lumen proportionaliter deficere secundum defectum in sole, et augmentabitur per eius augmentum[1] et decrescet secundum ipsius decrementum. In hoc solum erit differentia, quod pars deficiens in lumine opposita erit parti deficienti in sole, ita quod, si pars orientalis solis deficiat, in lumine pars occidentalis[2] deficiet, et e converso. Et hoc est propter intersectionem radiorum in ipso foramine; per ipsam enim fit radius veniens a dextra parte solis[3] sinister, et a sinistra dexter. – Per eandem etiam causam apparent in speculis concavis res eversae. – Et hoc quidem faciliter apparet in figura: Sit AB sol, C centrum foraminis, AD radius veniens a parte orientali solis, BE radius veniens a parte occidentali. Manifestum[4] quod, si A deficiat in sole, D deficiet in lumine cadente per foramen; ab eo enim causatur; et si B deficiat, E deficiet simili ratione.




**{40}** [5]Haec sunt quae per almanach[6] proposueram declarare; in quibus [7]si aliqua falsa vel dubia lector inveniat, ipsum rogo ut benigne corrigat vel exponat, **(PCN:)** et me multis qui aliquid scripserunt similem in hoc esse

[1] PU; augmentationem CN
[2] p.o.: illo p.o. N; *om.* P *a.c.*; o. luminis P *p.c.*; o. solis C; *alia* U
[3] v. a d.p.s.: PC; a p.s.d.v. U; solis v. a d. solis N
[4] est *add.* NU
[5] haec – perfectum: PC (*hic*), N (*ad finem textus*), U (*hic, sed verba* haec -- exponat *tantum praebet, deinde desinit*)
[6] p.a.: PCU; pro a. proposito N
[7] si -- benigne: PC, N *fere*; si quis aliqua dubia forsan inveniat, benigne queso U

intelligat secundum dictum Prisciani; dicit enim: In humanis inventionibus nihil reor esse perfectum.[1]

(*table: see at end*)

/P,44va; C,31ra/ **{41}** Feci praeterea hanc tabulam communem, per quam habetur[2] arcus diei, et numerus horarum diei aequalium, et partes horarum inaequalium, et aequatio dierum in minutis horae, et declinatio solis prout ponitur esse 23 gradus et 33 m'a. Composui autem eam ad annum secundum post bissextum, ita quod maior defectus, qui possit accidere ex ipsa, sit illud quod respondet dimidio gradui de praedictis, quod non est notabile.

**{42}** Compositionis vero modus hic est. Accepi per gradum solis prima die Martii anno domini 1294, qui est 18 gradus et 31 m'a <piscis>,[3] arcum diei, subtrahendo ascensiones huius gradus in septimo climate de ascensionibus nadair sive oppositi praedicti gradus, et remansit arcus de aequinoctiali qui elevatur prima die Martii ab ortu solis usque ad eius occasum; quem posui in directo primi diei Martii. Similiter per gradum solis in undecima die Martii inveni arcum diei et posui eum in directo illius undecimae diei. Similiter per gradum 21 diei et 31 Martii; postea per gradum 10 diei Aprilis et 20 et 30; et sic per additionem 10 dierum, quousque habui arcum diei per totum annum de decem in decem dies. Et ut faciliter /N,144v/ haberi possit[4] arcus /C, 31rb/ diei ad dies intermedios, posui in sequenti linea [5]differentiam arcus diei[6] [7]<decem dierum. **{43}** Deinde per divisionem arcus diei per 15 gradus inveni

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[1] Prisc. *Inst. Gr.* Prol. 3 (Keil II p. 2 lin. 13-14): "nihil enim ex omni parte perfectum in humanis inventionibus esse posse credo".
[2] h.: PC; habentur ad singulos 10 dies N
[3] N; *om.* PC
[4] h.p.: N; h. p()o p. P; posset h. C
[5] differentiam a.d. <**> aequalium – linea: *gem.* C
[6] CN; dierum P
[7] decem – horarum diei: *scripsi e.g.; om.* PC; decem dierum. Deinde per divisionem arcus dierum per 15 gra inveni numerum horarum equalium illorum 10 dierum N

numerum horarum diei> aequalium, quem[1] posui in alia linea, et similiter differentias horarum diei posui in alia, ut per eas faciliter habeatur numerus horarum diei ad dies intermedios. Per divisionem autem arcus diei per 12 habui partes horarum, quas posui in alia linea, et differentias similiter decem dierum in alia. Per gradum vero solis inveni aequationem dierum [2]et declinationem solis, quas similiter posui in aliis lineis, et differentias declinationis decem dierum similiter posui in alia linea; [3]differentias vero aequationis dierum non posui, quia parvae sunt.

**{44}** Habito autem arcu diei si subtrahatur [4]<de 360 gradibus, remanebit arcus noctis; similiter, habito numero horarum aequalium diei si subtrahatur> de 24 horis, remanebit numerus horarum aequalium[5] noctis; et similiter subtractis partibus horarum diei de 30 gradibus, remanebunt partes horarum noctis inaequalium, quia una hora diei inaequalis et una noctis continent 30 gradus. – Per declinationem vero solis potest sciri altitudo solis in meridie in qualibet regione, scita altitudine principii arietis in ea, quia si declinatio solis fuerit septentrionalis, addatur altitudini principii arietis, et si meridiana, subtrahatur.[6] – **{45}** Valet autem haec tabula maxime ad inveniendum ascendens per tabulas ascensionum in regione ad horam quamlibet post meridiem, quia /C,31va/ si numerus horarum aequalium post meridiem[7] multiplicetur per 15 et summae provenienti addatur /P,44vb/ medietas arcus diurni, habebuntur ascensiones aequinoctialis ab ortu solis. Quaeratur ergo simile in ascensionibus regionis, et gradus aequalis in directo ipsarum erit gradus ascendens. – Similiter valet multum ad

[1] CN; quam P
[2] et decl. – aliis lineis (lineis *om.* P): PC; per tabulam suam quam reduxi ad tempus, scilicet ad minuta horarum, et posui ea in tabula sequenti, differentias autem equation(um) h(uius) non posui quia parve sunt. Similiter per gradum solis inveni declinationem solis per tabulam suam et eam posui in sequenti tabula N
[3] diff. – sunt: PC; *om.* N, *cf. supra*
[4] de 360 – subtrahatur: N; *om.* PC
[5] n.h.a.: N; n.h. C; arcus P
[6] si merid. sub.: N; si merid. (!) C; sub. si sit merid. P
[7] preteritarum *add.* N

sciendum de qualibet coniunctione vera[1] vel oppositione, utrum sit diurna vel nocturna, quia, si horae ipsius coniunctionis vel oppositionis plus distent a meridie quam sit medietas horarum diei, nocturna erit; si vero minus, diurna.

**{46}** Potest autem haec tabula durare usque ad 60 annos absque errore notabili, quia in tot annis non movetur 8'a sphaera[2] per unum gradum, et illud, quod facit unus gradus de <diversitate in>[3] praedictis, notabile non est ut plurimum.

[1] c.v.: P; c. C; v.c. N
[2] n(isi)[[.]] *add.* P
[3] d. in: N; *om.* PC

**{47} (P,44r; C,30v; *desunt* NU:)**

**(1)** Menses – **(2)** Dies – **(3)** Arcus diurnus – **(4)** Differentia 10 dierum – **(5)** Numerus horarum diei aequalium – **(6)** Differentia horarum 10 dierum – **(7)** Partes horarum inaequalium – **(8)** Differentia [1]partium horae 10 dierum – **(9)** Aequatio dierum – **(10)** Declinatio solis – **(11)** Differentia 10 dierum

| (1) | (2) | (3) Gr | Mi | (4) Gr | Mi | (5) Ho | Mi | (6) Mi | (7) Gr | Mi | (8) Mi | (9) Mi | (10) Gr | Mi | | (11) Gr | Mi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mar | 1 | 169 | 41 | +8 | 53 | 11 | 19 | +35 | 14 | 8 | +45 | 5 | m 4 | 34 | A | -3 | 57 |
| | 11 | 178 | 34 | 8 | 48 | 11 | 54 | 35 | 14 | 53 | 44 | 8 | 0 | 37 | s | 3 | 54 |
| | 21 | 187 | 22 | 8 | 45 | 12 | 29 | 35 | 15 | 37 | 43 | 12 | s 3 | 17 | c | +3 | 49 |
| | 31 | 196 | 7 | 8 | 26 | 13 | 4 | 34 | 16 | 20 | 42 | 15 | 7 | 6 | e | 3 | 37 |
| Apr | 10 | 204 | 33 | 8 | 3 | 13 | 38 | 32 | 17 | 2 | 40 | 18 | 10 | 43 | n | 3 | 20 |
| | 20 | 212 | 36 | 7 | 35 | 14 | 10 | 30 | 17 | 42 | 40 | 20 | 14 | 3 | d | 2 | 57 |
| | 30 | 220 | 11 | 6 | 41 | 14 | 41 | 26 | 18 | 20 | 34 | 22 | 17 | 0 | . | 2 | 29 |
| Mai | 10 | 226 | 52 | 5 | 32 | 15 | 7 | 23 | 18 | 54 | 27 | 22 | 19 | 29 | | 1 | 58 |
| | 20 | 232 | 24 | 3 | 57 | 15 | 30 | 16 | 19 | 21 | 21 | 22 | 21 | 27 | | 1 | 19 |
| | 30 | 236 | 23 | 2 | 7 | 15 | 46 | 8 | 19 | 42 | 11 | 20 | 22 | 46 | | 0 | 42 |
| Jun | 9 | 238 | 30 | 0 | 1 | 15 | 54 | 0 | 19 | 53 | - 1 | 18 | 23 | 28 | | -0 | 1 |
| | 19 | 238 | 31 | -2 | 8 | 15 | 54 | - 8 | 19 | 52 | 11 | 16 | 23 | 27 | D | 0 | 40 |
| | 29 | 236 | 23 | 4 | 0 | 15 | 46 | 16 | 19 | 41 | 20 | 14 | 22 | 47 | e | 1 | 20 |
| Jul | 9 | 232 | 23 | 5 | 29 | 15 | 38 | 22 | 19 | 21 | 27 | 13 | 21 | 27 | s | 1 | 58 |
| | 19 | 226 | 54 | 6 | 44 | 15 | 8 | 27 | 18 | 54 | 34 | 12 | 19 | 29 | c | 2 | 29 |
| | 29 | 220 | 10 | 7 | 35 | 14 | 41 | 31 | 18 | 20 | 37 | 13 | 17 | 0 | e | 2 | 58 |
| Aug | 8 | 212 | 35 | 8 | 3 | 14 | 10 | 32 | 17 | 43 | 40 | 14 | 14 | 2 | n | 3 | 20 |
| | 18 | 204 | 32 | 8 | 28 | 13 | 38 | 34 | 17 | 3 | 43 | 15 | 10 | 42 | d | 3 | 38 |
| | 28 | 196 | 4 | 8 | 47 | 13 | 4 | 35 | 16 | 20 | 44 | 18 | 7 | 4 | . | 3 | 50 |
| Sep | 7 | 187 | 17 | 8 | 50 | 12 | 29 | 35 | 15 | 36 | 44 | 22 | 3 | 14 | | 3 | 56 |
| | 17 | 178 | 27 | 8 | 53 | 11 | 54 | 36 | 14 | 52 | 45 | 25 | m 0 | 42 | D | +3 | 55 |
| | 27 | 169 | 34 | 8 | 49 | 11 | 18 | 35 | 14 | 7 | 43 | 28 | 4 | 37 | e | 3 | 50 |
| Oct | 7 | 160 | 45 | 8 | 39 | 10 | 43 | 34 | 13 | 24 | 43 | 30 | 8 | 27 | s | 3 | 37 |
| | 17 | 152 | 6 | 8 | 6 | 10 | 8 | 32 | 12 | 41 | 41 | 31 | 12 | 4 | c | 3 | 21 |
| | 27 | 144 | 0 | 7 | 37 | 9 | 36 | 30 | 12 | 0 | 38 | 31 | 15 | 25 | e | 2 | 54 |
| Nov | 6 | 136 | 23 | 6 | 29 | 9 | 6 | 26 | 11 | 22 | 33 | 30 | 18 | 19 | n | 2 | 20 |
| | 16 | 129 | 54 | 5 | 2 | 8 | 40 | 20 | 10 | 49 | 24 | 28 | 20 | 39 | d | 1 | 43 |
| | 26 | 124 | 53 | 2 | 52 | 8 | 20 | 12 | 10 | 25 | 15 | 24 | 22 | 22 | . | 0 | 58 |
| Dec | 6 | 122 | 1 | 0 | 43 | 8 | 8 | 3 | 10 | 10 | 3 | 19 | 23 | 20 | | 0 | 12 |
| | 16 | 121 | 18 | +1 | 49 | 8 | 5 | + 7 | 10 | 7 | + 9 | 14 | 23 | 32 | A | -0 | 34 |
| | 26 | 123 | 9 | 4 | 1 | 8 | 12 | 13 | 10 | 16 | 20 | 9 | 22 | 58 | s | 1 | 22 |
| Jan | 5 | 127 | 10 | 5 | 45 | 8 | 29 | 23 | 10 | 35 | 30 | 5 | 21 | 36 | c | 2 | 3 |
| | 15 | *132* | 55 | 7 | 0 | 8 | 52 | 28 | 11 | 5 | 35 | 2 | 19 | 33 | e | 2 | 37 |
| | 25 | 139 | 58 | 7 | 57 | 9 | 20 | 32 | 11 | 40 | 40 | 0 | 16 | *56* | n | 3 | 7 |
| Feb | 4 | 147 | 55 | 8 | 27 | 9 | 52 | 33 | 12 | 20 | 42 | 0 | 13 | 49 | d | 3 | 29 |
| | 14 | 156 | 22 | 8 | 41 | 10 | 25 | 35 | 13 | 2 | 44 | 1 | 10 | 20 | . | 3 | 45 |
| | 24 | 165 | 3 | . | . | 11 | 0 | . | 13 | 46 | . | 3 | *6* | 35 | | . | . |

[1] p.h.: P; \partium/ horarum C

2.Mai30 30: 31 C. — 2.Jun9-Feb24 10,20,30, 10,20,31, ..., 30,10,20,28 C. -- 3.Mar1 169°:C; 167 P. — 3.Aug8 212: 112 C. –- 3.Jan15 132: 152 PC. — 4.Mar31 26′: 28 P *a.c.* –- 5.Mar31 13: 12 P. –- 7.Apr30 20: C; 27 P. –- 8.Apr20 40: PC. –- 9.Dec16 14: P; 10 C. -- 10.Dec6 23°: 22 P. –- 10.Jan25 56′: 58 P. — 10.Feb24 6°: 5 –- 10.Jun29 22°47′: C; *om.* P, *reliqua columna sursum mota.* –- 10.Dec6 23: C; 22 P. –- 10.Jan25 56: 58 PC. –- 10.Feb24 6: 5 P; 35 C. -- 11.Jun19 40′: C; 48′ P *mg.*; 4<.> P *a.c.*

# Canons: Translation

**{1}** As I am engaged in preparing an Almanach of the planets for 20 successive years counting from now, that is, from AD 1292, it will be helpful if I start out by explaining some points where the planetary positions to be found in my Almanach will be seen to disagree with the common tables. Indeed, this disagreement might give somebody occasion for doubting my work, and furnish others with material for detracting it, especially those who are easily moved by envy to criticize novel works.

**{2}** The first point that presents itself to be explained is why I assign the value I do to the motion of the eighth sphere at the present time, that is, AD 1292. (By "the motion of the eighth sphere" I understand the distance of the Head of Aries on the moveable zodiac -- located on the eighth sphere by the astronomers -- from the intersection of this zodiac with the equator. When the Sun arrives at this intersection, it causes equinox in all terrestrial climates.) This distance, indeed, I assert to be 10°15' at the present time, in spite of the fact that the corresponding distance, as found from Thebit's tables of accession and recession of the eighth sphere, is only 9°23' at the present time;[1] so this deviates from the truth by about one degree. **{3}** To find that the distance has the value stated, I did as follows: When the Sun was at the end of Gemini, I took its altitude in this region, namely Paris, and found it to be 64°44', and this is called "the altitude of the beginning of Cancer." Also, when the Sun was at the end of Sagittarius, I took its altitude and found it to be 17°36', and this is called "the altitude of the beginning of Capricorn."[2] From these

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[1] Table PA21 (Pedersen 2002, p.1547), for 1272y + 19y (1291y elapsed), gives a value of close to 61°. Table PB11.Lca (Pedersen 2002, p.1554; Toomer no. 81(iii)), with this value as argument, does indeed give the value of 9;22,58°.

[2] Reconstructed values: Obliquity of ecliptic, 23;31,43°; latitude of Paris (Observatory), 48;50,11°, co-latitude 41;9,49°. True solar altitude at summer solstice, 64;42°; at winter solstice, 17;38°. Refractions are less than +½' and about +3', respectively, so the altitudes William ought to have seen at the true solstices were 64;42-43° and 17;41°.

observations I established two things, namely, [first,] that the greatest declination of the Sun is 23°34'. This is obtained by subtracting the solar altitude at the end of Sagittarius from the solar altitude at the end of Gemini, because one half of the remainder is the greatest solar declination just indicated. **{4}** The other thing to be had in this way is the altitude of the north celestial pole in this region. Indeed, if the greatest solar declination is added to the altitude of the beginning of Capricorn -- or if it is subtracted from the altitude of the beginning of Cancer -- one obtains the altitude of the equator in the meridian; and this is equal to the distance of the zenith from the north pole, and in this region it is 41°10'. Again, since there are 90° from the zenith to the horizon, if the stated distance of the zenith from the pole is subtracted from 90°, the remainder will be the distance of the pole from the horizon, that is, 48°50'.

**{5}** These things having been established, I proceeded as follows. In AD 1290, on the 12th day of March, which was the Sunday on which they sing *Lætare Ierusalem*, I took the altitude of the Sun at noon, and this was 40°54'.[1] Now, in this region the Sun has a meridian altitude of 41°10' when it is in the equator, and this altitude is 16' greater than the one just mentioned. Further, around the Sun's arrival at the equator, the solar altitude increases by about 24' per day, or by 1' per hour. So it follows that the centre of the body of the Sun arrived at the equator 16 hours after noon on the 12th day of March in the year mentioned.[2]

Accordingly, in that year, the motion of the eighth sphere was 10°13'. Indeed, if one computes the place of the Sun for the hour just mentioned, by means of the tables established for the eighth sphere, one

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[1] Reconstructed solar altitude, 40;52,5°. The refraction would be about 0;1,8°, so the altitude William ought to have seen was 40;53,13°, and thus his observation is rather precise.

[2] Reconstructed: On March 12, noon, the solar declination was -0;17,44° ("-0;16°", William), and the solar longitude (tropical) was 359;15,48°. The longitude became zero at 17;53 hours after true noon on March 12 in Paris, against the 16 hours found by William.

finds that the true place of the Sun is 11 signs 19°47';[1] and when this value is subtracted from 12 signs, it shows the distance of the Head of the moveable Aries from the equator, that is, 10°13'.

**{6}** From this it seems possible to conclude, either that the motion of the eighth sphere asserted by Thebit has no truth to it, or else that it is subject to some shrinkage or error. And therefore it seems safest and most reasonable to me to follow the *magistri probationum* in the matter of this motion. They agree with Ptolemy in their way of describing it, in that they describe this motion as one which proceeds evenly from west to east in accordance with the motion of the planets. However, they disagree with him as concerns its quantity: in fact, Ptolemy asserts that the motion is 1 degree per 100 years, whereas the *magistri probationum*, such as Alzophi and others, say that it is 1 degree per 70 years; still others assert that it is 1 degree per 66 years, namely, Albategni and his followers.[2] The cause of this disagreement is the length of time between the observations of our predecessors; the *magistri probationum* had a longer period of time at their disposal than Ptolemy had had, and so they were in a better position to assess the truth.[3]

**{7}** The second point that can now profitably be explained is why I subtract 40 minutes of an hour from the times of the mean conjunctions and oppositions of the Sun and the Moon. To this end, one ought to know that the time of true opposition is not always equal to the time of mid-eclipse, as some persons make it out to be; in fact, in some cases it is earlier, in others later, and in still others it is the same. Indeed, when the Moon approaches the node, whether the ascending or the descending one, then the time of true opposition is earlier than the time of mid-

[1] The Toulouse Tables (1290 March 12, noon + 16 hours; lookup: 1272y + 17y + no months + 12d + 16h) give the true longitude of the Sun as 11s 19;47,5°, in agreement with the text.

[2] William's motion of the 8th sphere is 10°13' for 1290 (§5) and 10°32' for 1311 (tables of Almanach, Par.lat. 16201, 218v), increasing by 19' during 21 years, or most closely 1° per 66 years. The series shown by the Almanach is: 10°15'-21' (1292-98), 10°21'-28' (1299-1306); 10°28'-32'(1307-11).

[3] Cf. Albattani, ch. 52 at end (Nallino I, 127-28).

eclipse; on the other hand, when it moves away from the node, then the opposite is the case, that is, the time of mid-eclipse is earlier than the time of true opposition; but when the Moon happens to be in the node at the time of mid-eclipse, then the time of true opposition and the time of mid-eclipse are equal. This is easy to see for anybody who considers the way in which the Moon enters and leaves the shadow; and it happens because the centre of the shadow is always on the ecliptic -- that is, the path of the Sun -- whereas the centre of the Moon is not; and the farther the Moon is from the node at mid-eclipse, the greater is the difference in time between mid-eclipse and true opposition. But in whatever order these occur, the time difference does not exceed 10 to 12 minutes of an hour.[1] **{8}** Thus, even if the eclipse tables were precisely correct, this would still entail that some true oppositions computed by means of the tables would occur before the corresponding mid-eclipses, whereas some others would be found to be later, and still others would occur at the same time. But this is not what happens at the present time; on the contrary, as has been determined on the basis of many eclipses, the time of mid-eclipse is always earlier than the true opposition computed from the tables, even if, as was said, it ought to be now earlier, now later, now at the same time, had the tables been correct. Indeed, an eclipse has been found that was more than an hour earlier than the true opposition computed from the tables; another one was found to be merely 20 minutes earlier; and some others were earlier by 45 minutes, by 30 minutes and by several other intervals, all less than an hour and greater than 20 minutes. I could put down instances of these, since I have

[1] For the difference between mid-eclipse and true syzygy (i.e., the point where the Moon and the shadow attain the same longitude), see already *Almagest* VI 7, Toomer 1998 p. 297. -- The "10 to 12 minutes" can be guessed from a rectilinear eclipse figure where the inclination of the lunar orbit against the ecliptic is 5°, and the Moon barely touches the shadow externally at "mid-eclipse". The sum of the two radii may be taken as 1;3,34° (from Cb194-96), so that the arc the Moon has to travel is 0;5,34°, which should be multiplied by 13/12 to take account of the fact that the shadow has its own motion (Cb202), giving 0;6,2°. Divide this by the (maximum) velocity of the Moon, say, 0;36,3°/h (Cb194), and you will get 10m2s for the traversal time; or by the minimum velocity of 0;30,18°/h (table JA11) to get 11m57s.

observed them, but the risk of being boring and long-winded keeps me from it. **{9}** In short I believe that, at the present time, no eclipse is seen which does not precede its true opposition by at least 20 minutes. This seems to entail that there is some error, not only in the mean motion of the Moon, but in the argument of the Moon as well. (The computation of the Sun I assume to be correct.) Indeed, since the mid-eclipse is always earlier than the corresponding true oppositition computed from the tables, it follows that there is an error in the mean motion. For if the error was in the argument only, it would follow that the mid-eclipse would sometimes be earlier than the true opposition computed from the tables, and sometimes later; and this is not the case. On the other hand, since it is not earlier in a uniform way, but now more and now less, it follows that there is an error in the argument. Indeed, this diversity cannot be sufficiently accounted for by means of the cause mentioned earlier, that is, by means of the variation due to how the Moon enters and leaves the shadow, as this did not exceed 10 to 12 minutes. (Still, this variation may form part of the diversity in question.) **{10}** For these reasons I decreased the times of the [computed] mean conjunctions and oppositions by 40 minutes, this being midway between one hour and 20 minutes of an hour; and this is in order to correct the mean motion of the Moon. As for the error due to the argument, I have not yet determined how great it is; however, it is less than the error due to the mean motion. These 40 minutes correspond to just 22 minutes of arc in the lunar mean motion; and this seems to be the amount by which the table of lunar mean motion for collected years is behind at the present time.[1] This may have come about because the tabular value for the daily motion of the Moon is short by some minutes or seconds; and if these have been accumulating since the time when the tables were made, they may not have produced any perceptible error to begin with, but by now they

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[1] The Toulouse mean motion table has 0;21,57,20°, in agreement with the text. -- Though William does not say so explicitly, he has in fact used the +22' as a correction for the lunar mean motion in the *Almanach*, cf. Appendix, Tables. Also, Peter of St Omer (ref., see introduction) accepts this correction on a par with the corrections for Saturn, Jupiter and Mars. The correction has been introduced in the two lunar calculations in §20-21.

may have accumulated into a number of minutes that constitute a perceptible error.

**{11}** As for Saturn and Jupiter together, I ascertained the following with the unaided eye.[1] In AD 1285, on Friday after Christmas, after sunset, I saw Saturn and Jupiter, and Jupiter was still behind Saturn by about half a degree. In the same way I observed them on the next day, Saturday, and then they were a little less apart than before, such that, according to an estimate, their conjunction seemed due to occur on the last day of December, that is, on the following Monday, and not earlier.[2] On the other hand, according to the Toulouse Tables, by then Jupiter would have been ahead of Saturn by more than two degrees;[3] and thus, from the tables, they were found to be in conjunction more than 15 days before they really were.[4] According to the Toledan Tables, the case is similar, and the deviation is even greater than with the Toulouse Tables. **{12}** According to this observation, it appears that the mean motion is

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[1] *ad oculum*, in contrast to using a sighting instrument such as the *armillae*, §20; cf. also §25.

[2] Reconstructed: On Friday after Christmas AD 1285, or Dec 28, Jupiter and Saturn were visible at sunset (at altitude 13°.7), Jupiter being behind Saturn by 22.6 minutes in longitude ("about ½°", William). On the next evening, the elongation would have been some 7 minutes less. The conjunction was indeed on the night after Dec 31, at 21h32m true solar time; at that time Jupiter and Saturn were not visible.

[3] True places in the 8th sphere, computed from Toulouse Tables for 1285 Dec 31 (at noon, arbitrarily, since William offers no guess at the time of day): Saturn 9s 27;12°, Jupiter 9s 29;12°; so Jupiter is 2°0' ahead of Saturn at noon. At a time "after sunset" this elongation would have increased by some 1½ minute, so this accords with William's "more than two degrees".

[4] True places in the 8th sphere computed from the Toulouse Tables for 15 days before Dec 31, that is, 1285 Dec 16, at noon: Saturn 9s 25;32°, Jupiter 9s 25;50°; so even 15 days back, Jupiter would still be 18' ahead of Saturn according to the tables. This elongation would have been about 7' less on the day before, thus zero about 2½ days before, or 17½ days before Dec 31. William may have estimated his "more than 15 days" somewhat loosely, or my computation may be some minutes off his, or both.

faulty, either for one planet or for both; and it seems more probable that there are errors in both motions, though the error is greater for Saturn. Thus, as I believe, the tabular mean motion of Jupiter is about 1° too great in the table of collected years, and that of Saturn is 1°15' too small or thereabouts. For by computing their places in this way -- that is, by subtracting about 1° from the mean motion of Jupiter, and by adding 1°15' or thereabouts to the mean motion of Saturn, as found from the Toulouse Tables -- one will find them in conjunction on the day mentioned,[1] when the conjunction occurred according to what was observed.

**{13}** This observation is also in agreement with one that was made 60 years earlier. I found the latter written down in the margin of a book, as follows, "In AD 1226, on the fourth day of March, that is, on Ash [Wednesday], about dawn, a conjunction of Saturn and Jupiter appeared, and this was visually detected by somebody." That is what it said; and from this I assume that Saturn and Jupiter were either in conjunction at the time stated, or else close to conjunction.[2] In fact, this conjunction took place in the same part of the heavens as did the one mentioned previously, that is, at the beginning of Aquarius; and here Saturn and Jupiter have about the same latitude, particularly when they are in direct motion, as indeed they were in both of the observations in

[1] Indeed, when applying these corrections, my computation from the Toulouse Tables happens to put both planets in the same place on noon of 1285 Dec 31, namely, 9s 28;17° in the 8th sphere. -- William does not provide data to show how he arrived at his corrections, nor why they were different for Saturn and Jupiter. They cannot rest on a comparison with the Toledan Tables because, e.g., the Toulouse mean motion of Saturn is already about 1½° in advance of that expected from the Toledan Tables; see Poulle 1994, pp. 62 and 81.

[2] Reconstructed: The conjunction was really on 1226 March 5, at 4h19m true solar time, some 2h before sunrise, and shortly before Saturn and Jupiter rose. Their latitude difference was only 2', cf. note below. At the stated date of "March 4", their elongation would be about 6' and may thus have been noticeable [Fab.]. But the intended dating is not in doubt, as "on Ash [Wednesday], about dawn" has to refer to the morning of March 4, not March 5.

question.[1] Thus neither observation ought to contain errors that are due to the latitude; and [so] in either case the place and time of the conjunction could be obtained closely enough, without notable error, without using an instrument. **{14}** Now, if one computes their places by means of the Toulouse Tables for the time mentioned -- that is, March 4th about dawn, AD 1226 -- one finds that Jupiter was already ahead of Saturn by more than 1 degree and a half. On the other hand, if one computes their places according to the method of correction just described, one finds that Jupiter was still behind Saturn by about a third of a degree.[2] This observation, then, although it is not in precise agreement with the preceding one, does come much closer to it than the tables do.[3] It is true that both observations could be affected by moderate errors, which in combination might cause this discrepancy.[4] -- **{15}** These, then, were the reasons that made me use the above method when computing the places of these two planets for the purpose of making the Almanach, instead of following the tables. However, I do not yet claim that the facts are exactly like this, as the motions may contain something that has escaped my attention but can later be made apparent by instrumental observation. But if anybody wants to follow [the tables], he can easily reduce the values for Saturn and Jupiter to those according to

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[1] Reconstructed: Longitudes: Aqr 2;58° for this conjunction, Aqr 8;2° for that of §11. -- Latitudes of Saturn and Jupiter: -0;29° and -0;27° here, -0;53° and -0;43° in §11, truly no great difference.

[2] Places computed for the 8th sphere from the Toulouse Tables (for 1226 March 4, 6h0m): *Uncorrected:* Saturn 9s 23;13°, Jupiter 9s 24;42°; Jupiter is 1°29' ahead of Saturn (William: "more than 1½°"). *Corrected:* Saturn 9s 24;19°, Jupiter 9s 23;45°; Jupiter is 0°34' behind Saturn (William: "about 1/3°"). The agreement is less than impressive, but often my calculations differ from William's by some minutes, cf. note to §11 and the statistics in *Appendix, Tables*.

[3] Intended sense, perhaps: The two observations are in agreement because both conjunctions can be reproduced from the tables when introducing the corrections indicated, cf. §20. The latter observation, however, shows an error of "about a third of a degree," but this is still a better fit than can be had when trying to reproduce either conjunction from the uncorrected tables (Jupiter ahead of Saturn by 2° in §11, by 1½° in §14).

[4] Does William mean "both calculations"? This would give sense to the expression "in combination" (*compositus*).

the tables, namely, by adding about 1 degree to the true place of Jupiter, and by subtracting 1°15' or thereabouts from the true place of Saturn; for [a difference of] 1 degree does not correspond to anything significant in the equation of *centrum*, or in the equation of argument, as concerns these two planets.[1]

**{16}** Now it is time to speak of Mars, which is found to be [more aberrant][2] than the others. On the basis of unaided observations I assume the following. On the night after the Friday that was the third day of March, AD 1290, Mars was in conjunction with the single star in the northern claw of the Scorpion, about the 21st degree of Scorpio. It was then still in direct motion, and leaving the star it travelled about 3° to reach its first station.[3] Then, becoming retrograde, it returned to the same star on the night after April 21st.[4] The first time, Mars was slightly

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[1] The "equation of *centrum*" and the "equation of argument" are the two terms to be added to the mean motion in order to obtain the true motion, see examples in the Appendix. The assertion is that these terms are not significantly affected by the small corrections applied to the mean motion; and thus the corrections displace the true motion about as much as they did the mean motion. So, given the corrected true motion, we may get back to the uncorrected by applying the correction in reverse. -- In the two calculations for Saturn (§11-12 and §14) the correction of +1;15° to the mean motion causes changes in the true motion of +1;05° and +1;06°; and for Jupiter, in the same way, the correction of -1° causes changes of -0;55° and -0;57°. So William does not seem to care about a difference of some minutes. I have not examined the general case.

[2] Several readings, all hard to interpret. The meaning seems to be that Mars needs a numerically greater correction to its mean motion (3°, below, against 1;15° or less for the other planets already treated). The same thing is emphasized in §24.

[3] First station reconstructed: On March 30, longitude Sco 26;42°.

[4] The star is Beta Scorpii, longitude (1290 Mar-Apr) Sco 23;17°-23;18°, latitude +1;6°. This was also identified by Harper 1966, p. 50, though tentatively. -- Reconstructed: The two conjunctions were really on 1290 March 4, true solar time 11h46m (while "on the night after March 3" Mars rose at 23h18m and may thus have been visible from a little before midnight), and on 1290 April 21, true solar time 20h02m (while "on the night after April 21" Mars rose at 20h26m).

to the north of the star, at a distance of 12' or thereabouts; the second time, it was to the south of it, at a distance in latitude[1] that was about three times the distance it had the first time, when it was to the north.[2] **{17}** Thus, in order to correct the motion of Mars, I used the solar mean motion in the present two observations as a basis. Then I varied the mean motion of Mars until, for the two observations, I had mean motion values that yielded one and the same place for Mars, as it had been in the observations. (For this purpose one also has to use the argument of Mars; this is obtained by subtracting the mean motion of Mars from the mean motion of the Sun, which was left unchanged.) To get this result, I found that one has to subtract 3 entire degrees or thereabouts from the mean motion of Mars as found from the Toulouse Tables.[3] These 3

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The first observation might have been as much as 12 hours earlier than the real conjunction, corresponding to a deficit of some 7' in the longitude of Mars; in the second observation the error would be less.

[1] All four mss. read *latitudine*, and this is surely the intended reading, since at the beginning of §17 William assumes Mars to have had the same "place", i.e., longitude, for the two observations. William must normally have thought his conjunctions were the real ones, even though he did not use an instrument, cf. §24. Thus the term "altitude", which occurs as a textual variant in other places, should probably never be accepted. See also note to §20, "aligned".

[2] Reconstructed: At the real conjunction in March, Mars would be 19' to the north of the star, and at that in April, 64' to the south. The latitudes of Mars would be practically the same at the times of night when the near-conjunctions were visible to William (see note above), so his estimates of the differences in latitude (12' and three times 12') are low though his proportion of 1:3 is close to reality. -- Where William got his expression "single star in the northern claw of the Scorpion, about the 21st degree of Scorpio" is yet to be determined. The real longitude would be the 23rd or 24th degree of Scorpio; but William's figure corresponds to the longitudes of Mars which he could obtain by computation, see note below. The star is not in the usual catalogues that accompany the Toledan Tables, and to judge from William's account of his method, its longitude would be immaterial. The estimate from Albattani would be about Sco 23;53° for AD 1290.

[3] Thus, when applying the correction of round -3° and computing the longitudes of Mars from the Toulouse Tables for 1290 March 3 and April 21, midnight, one should get similar longitudes. My calculation yields the longitudes 7s 10;49° and 7s 11;1° in the 8th sphere, respectively, with a

degrees of error in the mean motion entail the same amount of error in the *centrum*, and also in the argument, although in opposite directions, as they are subtracted from the mean motion and the *centrum* but added to the argument. **{18}** But the error in the computation of the true place of Mars, caused by these 3 degrees, varies for the different parts of the heavens. Thus, when the centre of the epicycle is in the apogee of the deferent, and the body of Mars is in the apogee of the epicycle, then the error caused by the said 3 degrees is at its minimum. Indeed, in this case, when computing the place of Mars by means of the tables, one finds an error of only 1°32', because the error in the mean motion is decreased by the error in the equation of *centrum* as well as in the equation of argument.[1] **{19}** But when the centre of the epicycle is in the perigee of the deferent, and the body of Mars is in the perigee of the epicycle, then the error caused by the said 3 degrees is at its maximum. Indeed, in this case, when the place of Mars is computed by means of the tables, these are found to be in error by 13°34'. For the 3 degrees in question correspond to 40' of the equation of *centrum*, which are to be added to the 3 degrees when finding the corrected argument; and these 3°40' correspond to 7° of the equation of argument, and to 2°54' of the variation of epicyclic diameter, which is in the "near distance" in this case. When all these values are added to the 3°, the sum is 13°34'; and this is the amount by which the place of Mars, as found from the tables,

difference of 12'. [Advancing each of the times from midnight to close to dawn (by 6h and 4h, for hourly velocities of +0'.6 and -0'.8) would give the longitudes 7s10;53° and 7s10;58°, or, in the 9th sphere, Sco 21;6° and Sco 21;11° (motion of 8th sphere 10°13', cf. §5); but this is probably to overtax the overall precision.] This calculation, if shaky, may illustrate why William estimated the conjunction to have taken place "about the 21st degree of Scorpio" (§16) instead of 2 degrees further on, as he might have said had he known the longitude of the star independently.

[1] Because of the two apogee positions mentioned, the real (mean) *centrum* and the real (mean) argument are both zero. Since, however, the mean motion is 3° too large, the faulty *centrum* is 3°, and the faulty argument is 11s 27°. Then the equation of centrum will be -0;33°, and the corrected equation of argument, -0;56°, totalling -1;29°. This total, when applied to the faulty mean motion, will bring its excess of 3° down to 1;31°, in fair agreement with the text.

is greater than it is in reality, on account of the original 3°.[1] For positions between the apogees and the perigees, an error will occur that is between these extremes.

**{20}** And I have confirmed the above in AD 1292, on the night after the first day of July, which was Tuesday before the feast of St Martin in the summer, Mars being retrograde in Capricorn. At midnight I saw the Moon aligned[2] with Mars, and by examination with the *armillae* I found the Moon to have passed Mars by just about 1 degree.[3] Now when the place of the Moon is computed for the said time by means of the Toulouse Tables, with the addition of the motion of the eighth sphere, it is found to be in the 26th degree of Capricorn; and when the place of Mars is computed for the same time by means of the same tables, also with the addition of the motion of the eighth sphere, it is found to be in

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[1] Re-calculation from tables, cf. the note above on §18: In the perigees, the real *centrum* and the real argument are both 6 signs, but because of the +3° error in the mean motion, the faulty *centrum* is 6s 3° and the faulty argument 5s 27°. Then the equation of centrum will be +0;40°, the corrected equation of argument, +9;50°, and their total, +10;30°, which augments the +3° error in the mean motion up to 13;30°. -- William has 4' more than this, mainly because he has taken the variation of epicyclic diameter of 2;54° to be "in the near distance" and thus left it unchanged, whereas, according to the vulgate reading in table EA61.Pro (lookup with corrected centrum of 6s3;40°), it should have been multiplied by 59/60, to make 2;51°. Cf. Appendix.

[2] "I saw the Moon straight (*recte*) with Mars". *Recte* occurs only this once in our text, and might possibly mean "vertically". But at midnight after 1292 July 1, the Moon was about 1½° to the east of Mars in azimuth, for an altitude difference of some 6° (see note below), so nothing definite can be concluded in this way. Of course, here and below, some of the imprecision may reside in William's determination of midnight. -- "Aligned vertically" could in fact be expressed explicitly: cf. "were in the same azimuth", in section *Tables, Glosses,* Vat. 6v, "1292" February.

[3] Reconstructed for AD 1292, midnight after July 1 (solar azimuth 180°): *Mars,* longitude Cap 23;58°, latitude -6;4°, altitude 13°.4, azimuth 352°.30. -- *Moon,* longitude Cap 25;41°, latitude +0;13°, altitude 19°.8, azimuth 351°.04. -- Thus the Moon is 1;43° ahead of Mars in longitude, against William's "about 1°". The difference of over 6° in both latitude and altitude would indeed justify the use of an instrument.

the 7th degree of Aquarius. Thus the tables are found to be in error by more than 11 degrees (as they were not in the place where the maximum error is due to occur).[1] But if the place of Mars is computed by the method above -- that is, by subtracting 3 degrees from the mean motion at the start of the computation, and then going on according to the precepts of the canons -- then, at the time stated, Mars will be found to be in the 25th degree of Capricorn, as it was found by the said observation, that is, one degree behind the Moon.[2] And so this observation confirms the previous one.[3] -- I have also made several other observations [of Mars] together with the Moon and other bodies, by means of which I could confirm the same thing; but this would be prohibitively boring, so let these observations suffice for now.

**{21}** As for the fact that occasionally the 3 degrees of error cause [an error of] only 1°32' in the computation of the true place of Mars, I confirmed this in AD 1285, on the first day of [July], before sunrise, when Aldebaran had an altitude of 12°;[4] for at that time I saw the Moon

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[1] Longitudes computed from the Toulouse Tables for AD 1292, midnight after July 1, for the 8th sphere (=computed value) and for the 9th sphere (=computed value with the addition of William's value of 10°15' for the motion of the 8th sphere in 1292): -- *Moon, corrected:* Cap 15;40° (8th); Cap 25;55° (9th). -- *Mars, uncorrected:* Cap 27;25° (8th); Aqr 7;40° (9th). -- In common parlance, Mars would not be in the "7th degree of Aquarius" but in the eighth degree, but I trust both the text and my calculation.

[2] In fact, with the correction introduced, the tables yield: *Mars, corrected:* Cap 14;36° (8th); Cap 24;51° (9th). -- Thus Mars is indeed "in the 25th degree of Capricorn", or "1 degree behind the Moon" (1°4' behind the Moon according to the calculation). -- In the tables of the Almanach (Vat. lat. 4572, 2v-3r), by linear interpolation, we find the longitude of Mars to be Cap 24;45° (9th) on July 1, midnight, and that of the Moon to be Cap 25;54° (9th), in fair agreement with the corrected Toulouse values. -- (Note that in the case of the Moon we should interpolate between the values for June 30, <noon> + 16h17m and July 1, <noon> + 16h17m; for this see §26-27).

[3] The meaning may be that both observations justify the correction introduced. Cf. note to §14.

[4] The manuscripts are unanimous about the date of 1285 June 1 (not July 1), the time before sunrise, and the altitude of Aldebaran of 12°, except that ms. P omits the daynumber. In fact, as reconstructed, the conjunction was on the 2nd

together with Mars.[1] It will be possible to observe the same thing in AD 1293, in May or in June, if it can be seen;[2] for then the centre of the epicycle will be close to the apogee of the deferent, and the body of Mars close to the apogee of the epicycle.[3] -- **{22}** Thus, if anybody follows the

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of June, not the 1st as stated, and at 5h20m true solar time, after sunrise. Further, at the beginning of June, Aldebaran would perhaps be briefly visible during twilight but could not attain an altitude of 12° before sunrise. The easiest textual correction is to read July 1 for June 1, as I shall do in the following. -- On 1285 July 1 there was in fact a visible conjunction of the Moon and Mars at 3h28m true solar time, longitude 68;54°, latitude of Moon +0;46°, latitude of Mars +0;1°; Aldebaran was at altitude 12° at 2h51m; and sunrise was at 4h02m. All this fits the text very well. -- As an approximation I shall take the time to be 03h on the morning of July 1.

[1] The statement is convoluted and too brief, but the sense seems to be: The elongation at the observed time of conjunction (1285 July 1, say, at 03h, cf. note above) is in fact zero; so if the tables show an elongation, this reflects the tabular error in the place of Mars [assuming that the place of the Moon is correct]. -- Longitudes computed from the Toulouse tables, in the 8th sphere (computed) and in the 9th sphere (adding 10°9' for the motion of the 8th sphere in 1285, cf. §2 and note to §6): -- *Moon, corrected, 03h:* 58;52° (8th), 69; 1° (9th); -- *Mars, uncorrected, 03h:* 60;24° (8th), 70;33° (9th); -- *Mars, corrected, 03h:* 58;24° (8th), 68;33° (9th). -- Thus the uncorrected Mars is indeed 1;32° ahead of the Moon, corresponding to the minimum error of +1;32° in Mars's place, asserted here and in §18. -- This may seem somewhat of a coincidence, since William does not say what time he has used for his table lookup. If the time is realistic, then at least he has failed to tell us that, at the same time, the corrected Mars is 0;28° behind the Moon (for a reconstructed latitude difference of only 0;45° at the time of the real conjunction, see note above), so that his corrections do not lead to a precise estimate of the conjunction he has observed himself.

[2] From Tuckerman, there were conjunctions of Mars and the Moon on 1293 May 10, 1h UT, and on 1293 June 7, 15½h UT. The latter would be by day and thus not visible (which William apparently has not cared to check).

[3] For the conjunction times on 1293 May 10 and June 7, the *centra* (=distances from the apogee of the deferent) are 11s 4° and 11s 16°, and the arguments (=distances from the apogee of the epicycle) are 10s 10° and 10s 25°, respectively, so we are not too far from the apogee positions. For the conjunction on 1285 July 1, 03h, the values are, however, 9s 6° and 1s 29°, which fit the rule badly, even if the tabular error was near minimum, cf. note above.

tables in every respect, let him take heed of the preceding, and consider how discreditable errors he can make in all kinds of judgments. Indeed, it is no wonder that people have been led astray in their judgments by following the tables, since the real-world conjunctions, applications and separations of the planets in relation to each other, not to speak of the real directions, are very different from those which are obtained by means of the tables. This is easily apparent to everybody from what has been said here.

**{23}** As concerns Venus and Mercury, I present no corrections here. I have indeed made several observations of them, as I have of the others, but the error I have been able to ascertain in their motion in this way is none or slight. [Thus] I assume that the same is true for them as for the Sun and Moon, namely, that their rapid motion has the effect that their motions can be corrected at smaller intervals and in a better way than the motions of the others. Indeed, their mean motion is the same as the mean motion of the Sun. This makes me believe that the tables will yield more realistic places for Venus and Mercury than for the rest.

**{24}** As concerns Mars, however, it is quite surprising that so great an error has been left in its motion right down to the present time. However, the reason might be that it rarely happens that Mars is retrograde and closely passes a fixed star twice, once when direct and again when retrograde, as was the case in the two observations described above. Further, in each observation it was close in latitude[1] to the star, so that the time of conjunction could be estimated precisely enough without an instrument. Also, in the first conjunction it passed above the star, and in the second, below it, so that while passing it described a line like this:

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The values cited in this note do not include William's -3° correction. I have not examined the validity of William's rule.

[1] According to William's estimate in §16: 12' north of the star, then three times as much south of it. For this, cf. note to §16.

**(1)** Mars passing above star -- **(2)** Star in northern claw of Scorpion -- **(3)** First station of Mars -- **(4)** Mars passing below star while retrograde -- **(5)** Second station of Mars -- **(6)** Mars in direct motion after second station -- **(7)** Southern claw of Scorpion -- **(8)** Heart of Scorpion

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------------------(1)------------------
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|                 (2)
(3)
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------------------(4)------------------
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                                     (5)
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                                      |
------------------(6)------------------

           (8)           (7)
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**{25}** In fact it rarely happens that it makes a passage like this around a fixed star, or around a slowly moving planet; and even if this has happened occasionally, no one was there to observe it; or if anyone was, it has not come down to us. Many such observations might have served for correcting some planetary motions, but they pass by without being recorded by anyone. I also think that it has been a long time since any observations were made by means of instruments in order to correct the places of the planets or even of the fixed stars. But I hope that soon, with the help of God, an instrument will be made that can serve for correcting such places; and I also hope that the corrections made by means of this instrument will not deviate, or deviate but slightly, from those made with the unaided eye.

**{26}** It should also be known that, throughout the Almanach, the places of the Sun and the five planets other than the Moon have been computed for noon on the day where their places in the ninth sphere are entered, such that, according to the way of the astronomers, a day begins at noon of the preceding day, and ends at its own noon. -- The place of the Sun has been computed for every day, in degrees and minutes. -- The places of the three superior planets, Saturn, Jupiter and Mars, have been computed in degrees and minutes for every tenth day; for the intermediate days they have been computed in degrees only, with values according to the relation between one [ten-day] value and the next. -- The places of Venus and Mercury have been computed for every fifth day in degrees and minutes; for the intermediate days they have been computed in degrees only, with values according to the relation between one [five-day] value and the next. -- The place of the Moon has not been computed for noon, but always for the hour of mean conjunction or opposition in the ninth sphere; and during the 14 days between mean conjunction and mean opposition, it has been computed for an hour corresponding to that of the preceding mean conjunction or opposition. **{27}** And in order to show the hour for which the place of the Moon has been computed, at the bottom of the page for each month I have put the time of mean conjunction and the time of mean opposition for that month. However, occasionally it happens that the Moon's place for the last of the 14 days falls between the same two noons as does the place for the following conjunction or opposition, which means that one of these places has to be put outside the table; and it is more reasonable that the place for the last day should be put outside, so this is what I have done. **{28}** Opposite each mean conjunction and opposition I also put the mean motion of the Moon in the eighth sphere at the time of the mean conjunction or opposition in question. And from this one may obtain the mean motion of the Sun because, in conjunction, the mean motion of the Sun and the Moon is the same; in opposition, one obtains the mean motion of the Sun by adding 6 signs to the mean motion of the Moon. And if we want to have it for the ninth sphere, we add the motion of the eighth sphere, which is listed in March in every year. -- I have also listed the argument of the Moon at the same times, that is, for the mean conjunction and opposition, for use in determining where the Moon is on its epicycle, and so whether its motion is slow or fast. -- In addition I have listed the velocity of the Sun and of the Moon, that is, the corrected velocity for one hour. The solar velocity is to be used for determining the true place of the Sun at the hour of mean conjunction or opposition: to do this, multiply it by the number of hours since noon until the hour of mean conjunction or opposition, and add the product to the true place of the Sun at the noon in question.

**{29}** The hourly velocity of the Moon has been listed with a view to easy determination of the time of true conjunction and opposition, after obtaining the true place of the Sun at the time of mean conjunction or opposition (in the way already described) and the true place of the Moon at the same time (which is listed in the Almanach). Take the difference between the true places of the Sun and the Moon at mean conjunction or opposition, and add its twelfth to it, and divide the sum by the velocity of the Moon at the time corresponding to the said mean conjunction or opposition; the result will be the time interval between the mean conjunction or opposition and the true one. Now if the Sun is ahead of the Moon, add this interval to the time of mean conjunction or opposition, and you will get the time of true conjunction or opposition for mean [solar] days; but if the Moon is ahead, then subtract this interval. Then find the equation of time and add it to the time just mentioned; and you will get the time of true conjunction or opposition for equated days. -- **{30}** And from this it is also easy to find when there will be a lunar eclipse. Indeed, when you have found the true opposition, see whether it is at night by comparing the time of true opposition to half the length of daylight on the day in question; and if the time of true opposition is farther from the preceding or following noon than is indicated by half the length of daylight, the opposition will be at night. Then, if the Sun and the Moon are closer than 12° to the ascending or the descending node, the size of the eclipse can be obtained accurately enough by proportionally applying the argument of lunar latitude[1] to the two tables for the far distance and for the near distance. But I nevertheless intend to list the times and the sizes of both solar and lunar eclipses throughout the Almanach.

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[1] The tables are JD21 (Pedersen 2002, pp. 1467-70), Toomer no. 60. For using them one needs the argument of latitude, and normally also the argument of the Moon, cf. Cb200-201a. There may be a slight lacuna in the text.

**{31}** Once again[1] I have also listed the lunar latitude in the Almanach, for every day, and at a time of day equal to that for which the place of the Moon has been computed; and I have noted whether it is northern or southern, descending or ascending. Indeed, this is very useful and necessary for judgments.

**{32}** How much I have accomplished by preparing this work, and how much labour I have spared those who profess the noble science of judiciary astrology, will be easily apparent to anybody who gives any thought to it. Indeed, they now possess 20 years' worth of that noble and marvellous dance of the planets, which, as Plato says in the *Timaeus,*[2] is known by only a few. But how many pains I have taken, and how many expenses I have incurred in order to prepare my work, can only be assessed by someone who has collaborated with me.

**{33}** Nor should one think, as some do, that when the time period of this Almanach has passed, wholly or in part, then the part of the work that belongs to the past has become useless and unimportant; on the contrary, both the past and the future time should be taken into account as much as the present. For in order to know the state of a thing belonging to the present or future, it is not enough to consider the disposition of the heavens in the present or future; the disposition in the past has to be taken into account as well. For instance, to know the accidents of some year (?)of a nativity, it is not enough to look at the disposition of the heavens at the revolution of the year in question; one also has to consider the disposition of the heavens in the hour of nativity, which belongs to the past, and one has to compare the one with the other. Revolutions of world-years present a similar case; there, it is not enough to consider the conjunction before the revolution itself, but one has to go back to the conjunction before the minor conjunction of Saturn and Jupiter that immediately (?)precedes the revolution, as is

[1] *de novo:* the meaning is perhaps "in addition to the well-known listings in the common astronomical tables"; these listings are not, however, calendrical like the present ones.
[2] 40c-d.

apparent from Proposition 65 of Ptolemy's *Centilogium,* {the same thing should be done in questions, but there it seems less [necessary] for making secure and adequate judgments, as it appears} from Haly's explanation of the said proposition, and from several other authors.

**{34}**[1] But as I intend to list the places and times, and also the sizes, of the solar and lunar eclipses in the Almanach -- though, in fact, no solar eclipse of less than half size can be observed by the naked eye unless it falls near sunrise and sunset, such that the sunlight is weakened by intervening vapours, which is, however, a rare occurrence -- in view of this, I here intend to describe an experiment through which any solar eclipse can be observed, no matter how small it is, even down to an obscuration of only half a digit.[2] In this way I want to prevent any such eclipse from being taken as erroneously listed in the Almanach because it cannot be observed due to faulty vision. **{35}** I also want to prevent the accident that happens to those who watch the eclipses directly, such as that suffered by several persons on the fourth of June, 1285.[3] Indeed, since they stared fixedly at the Sun though the eclipse was of a small size, those who had their gaze thus fixed on it suffered a dimming of their eyes like that which normally occurs to those who enter the shade after having been out in the sunlight; and for some, this dimming lasted for two days, for others, three days or even more, according to how intently and for how long they had gazed at the Sun, and perhaps also according to how receptive their eyes were to this dimming. In this way, it seems that one may stare so much at the Sun that one becomes completely blind, according to the saying of the Philosopher: Excess of sensibles corrupts the sense.[4] The cause of this accident will, however, be explained elsewhere. **{36}** Some have the custom of watching an eclipse

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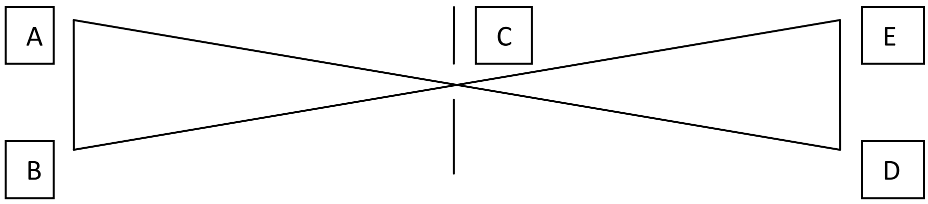
[1] §§34-39 have been edited with comments by Mancha 1992. That edition should be consulted for further information.
[2] A digit, *punctus,* is a twelfth of the solar diameter. A total solar eclipse has a size of 12 digits.
[3] Oppolzer 1885, I no. 5945, p. 238-39. For Paris: maximum 0.43 solar diameters, at 18h51m UT+1 [Fab.]
[4] Aristotle, *De Anima* II, 12, 424a29-30.

in a basin of water; but this is not enough, because the sunlight is reflected from the water, even if the reflected light is less strong than direct light; but the reflected light may also cause this accident, albeit in a weaker manner. However, if one proceeds in this way, one should properly use clear water in a deep vessel that is in a quiet place.

**{37}** So, in order to avoid the aforementioned accident entirely, let us describe another experiment by means of which, without eye damage, one can observe not merely a solar eclipse, but also the times of its beginning and end, and measure its size in digits, and still other things, though they belong elsewhere. In a closed house, make a hole in the roof or in a window, in the direction where the solar eclipse is due to take place; and the hole should be as big as the one through which you tap wine from a barrel. As the sunlight enters through this hole, place a board or some such plane object at a distance of 20 or 30 feet from it, such that the sunlight falls perpendicularly on the surface of the object. The light, as it falls on this surface, will appear perfectly round, even if the hole is angular; it will also be larger than the hole; and the farther the plane object is from the hole, the wider the incident light will appear, though it will be dimmer than if the distance is short. **{38}** And assume that a circle is described from the center of the hole, if the hole is small – or, if it is big, then from the intersection of the outer solar rays outside the hole – as far as the place where the light falls, such that the centre of this circle is the centre of the hole, or the intersection of the outer rays, and the circumference passes the place where the light falls. Then it will be found that the light, in the place where it falls, will cut off an arc of the circle proportional to the diameter of the Sun in the heavens; thus, if the diameter of the Sun in the heavens is 30', then the diameter of the light will also cut off 30' of the circle, and if the Sun's diameter is greater, then it will cut off that much more. – This seems to be a way of establishing the solar eccentricity by inspection, assuming that it is more reasonable for the Sun to have an eccentric than an epicycle, as it must have one or the other. Indeed, when the Sun is in its apogee, it is farther from the Earth than when it is in its perigee; and so it must appear smaller, and in the same way, the light that falls on the plane object through the hole must be smaller. – **{39}** When this set-up has been made, one should watch the light falling on the plane object at the time when the eclipse is due to occur; and when the eclipse begins, this light will be seen to dwindle in proportion to the dwindling in the Sun, and [the dwindling] will increase as much as [the dwindling of the Sun] increases, and decrease as much as it decreases. The only difference will be that the dwindling part of the light will be opposite the dwindling part of the Sun; thus, if the eastern part of the Sun dwindles, then the western part of the light will dwindle, and vice versa. And this is due to the crossing of the rays in the hole, since because of this the ray that comes from the right-hand side of the Sun is directed to the left, and the left-hand ray is directed to the right. (This is also the reason why things appear inverted in concave mirrors.) And this can be easily seen in the figure: Let AB be the Sun; C, the centre of the hole; AD, the ray that comes from the eastern part of the Sun; BE, the ray that comes from the western part. Then evidently, if A dwindles in the Sun, D will dwindle in the light passing through the hole, since D is caused by A; and if B dwindles, then E will dwindle for a similar reason.




**{40}** This is what I had intended to explain concerning the Almanach. If the reader finds anything here that is false or doubtful, I ask him to correct it or draw attention to it benevolently, and to be aware that in this respect I am similar to many other writers, according to Priscian's dictum; for he says, "Among human inventions I believe that none are perfect.[1]"

[1] Priscian, *Instit. Gramm.*, Prol. 3 (Keil II p. 2 lin. 13-14).

(Table, see §47)

**{41}** Furthermore I have made the present general table, which shows: (3-4) the daily arc; (5-6) the number of equal hours of the day; (7-8) the parts of unequal hours; (9) the equation of time, in minutes of an hour; (10-11) the declination of the Sun, assuming a [maximum] declination of 23°33'. I have prepared the table for the second year after a leap-year; in this way, the tabular error in any of the quantities mentioned cannot be greater than what corresponds to half a degree [in the solar longitude], and this is negligible.

**{42}** The table has been prepared in the following way. Using the degree of the Sun on the first day of March, AD 1294, which is Psc 18°31',[1] I took the daily arc by subtracting the ascensions of this degree in the seventh climate from the ascensions of the nadir, i.e., the opposite, of the same degree. The difference was the arc of the equator that rises between sunrise and sunset on the first of March, and this I put down opposite the first of March.[2] In the same way, using the degree of the Sun on the 11th of March, I found the daily arc and put it down opposite the 11th. I did the same thing with the degrees for the 21st and 31st of March, then with those for the 10th, 20th and 30th of April, and so on, always adding 10 days, until I had the daily arc for every tenth day throughout the year. And to make it easy to obtain the daily arc for the intervening days, I put the ten-day difference in daily arc in the next column of the table. **{43}** Then, by dividing the daily arc by 15 degrees, I found the number of equal hours of the day, and this I put in the next column; and similarly in the next column I put the differences of the hours of the day, to make it easy to obtain the number of hours of the day for the intervening days. Further, by dividing the daily arc by 12, I got the parts of hours, which I put in the next column, and similarly in the next column, the ten-day differences. And using the degree of the Sun, I

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[1] Thus also the tables of the Almanach and the Toulouse Tables (lookup: 1272y + 21y + 1d; add 10°17' for the motion of the 8th sphere from the 1294 page of the Almanach).

[2] Value 169;41° in the table §47. This value can be obtained by means of table BG17 of oblique ascensions for the 7th clime (Pedersen 2002, p. 1066; Toomer no. 26).

found the equation of time and the solar declination, which likewise I put in the next columns, and similarly in the next column, the ten-day differences of the declination. I did not note the differences of the equation of time, since they are small.

**{44}** If you have the daily arc and subtract it from 360 degrees, the difference will be the nightly arc. Likewise, if you have the number of equal hours of the day and subtract it from 24 hours, the difference will be the number of equal hours of the night. And likewise, if you subtract the parts of hours of the day from 30 degrees, the difference will be the parts of unequal hours of the night, because one unequal hour of the day plus one of the night contain 30 degrees. – The solar declination can be used to find the meridian solar altitude in any region, given the altitude of the beginning of Aries in the region; indeed, if the solar declination is northern, it should be added to the altitude of the beginning of Aries, and if it is southern, it should be subtracted. – **{45}** This table is particularly suitable for finding the ascendent by means of the tables of ascensions for the region, at any hour after noon. Indeed, if you multiply the number of equal hours after noon by 15 and add half the daily arc to the product, you will get the arc of the equator that has risen since sunrise. Find a similar arc in the [table of] ascensions for the region, and the ecliptical degree opposite it will be the ascendent. – The table is also very suitable for finding whether any true conjunction or opposition takes place during the day or the night. Indeed, if the time of the conjunction or opposition differs from noon by more than half of the hours of the day, it will be by night; if they differ less, it will be by day.

**{46}** This table can last until 60 years from now without appreciable error, because the eighth sphere does not move by one degree[1] during this number of years; and the difference that one degree makes to the quantities mentioned is mostly negligible.

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[1] Thus mss. CN; and all mss. say "60 years". -- Ms. P has "only moves by one degree"; but in fact William assumes a motion of less than one degree, namely, 1 degree in about 66 years, see note to §6.

**{47}**

**(1)** Months – **(2)** Days – **(3)** Daily arc – **(4)** Ten-day difference – **(5)** Number of equal hours of the day – **(6)** Ten-day difference of hours – **(7)** Parts of unequal hours – **(8)** Ten-day difference of parts of hours – **(9)** Equation of time – **(10)** Declination of Sun – **(11)** Ten-day difference

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gr Mi | Gr Mi | Ho Mi | Mi | Gr Mi | Mi | Mi | Gr Mi | | Gr Mi |
| Mar | 1 | 169 41 | +8 53 | 11 19 | +35 | 14 8 | +45 | 5 | m 4 34 | A | -3 57 |
| | 11 | 178 34 | 8 48 | 11 54 | 35 | 14 53 | 44 | 8 | 0 37 | s | 3 54 |
| | 21 | 187 22 | 8 45 | 12 29 | 35 | 15 37 | 43 | 12 | s 3 17 | c | +3 49 |
| | 31 | 196 7 | 8 26 | 13 4 | 34 | 16 20 | 42 | 15 | 7 6 | e | 3 37 |
| Apr | 10 | 204 33 | 8 3 | 13 38 | 32 | 17 2 | 40 | 18 | 10 43 | n | 3 20 |
| | 20 | 212 36 | 7 35 | 14 10 | 30 | 17 42 | 40 | 20 | 14 3 | d | 2 57 |
| | 30 | 220 11 | 6 41 | 14 41 | 26 | 18 20 | 34 | 22 | 17 0 | . | 2 29 |
| Mai | 10 | 226 52 | 5 32 | 15 7 | 23 | 18 54 | 27 | 22 | 19 29 | | 1 58 |
| | 20 | 232 24 | 3 57 | 15 30 | 16 | 19 21 | 21 | 22 | 21 27 | | 1 19 |
| | 30 | 236 23 | 2 7 | 15 46 | 8 | 19 42 | 11 | 20 | 22 46 | | 0 42 |
| Jun | 9 | 238 30 | 0 1 | 15 54 | 0 | 19 53 | - 1 | 18 | 23 28 | | -0 1 |
| | 19 | 238 31 | -2 8 | 15 54 | - 8 | 19 52 | 11 | 16 | 23 27 | D | 0 40 |
| | 29 | 236 23 | 4 0 | 15 46 | 16 | 19 41 | 20 | 14 | 22 47 | e | 1 20 |
| Jul | 9 | 232 23 | 5 29 | 15 38 | 22 | 19 21 | 27 | 13 | 21 27 | s | 1 58 |
| | 19 | 226 54 | 6 44 | 15 8 | 27 | 18 54 | 34 | 12 | 19 29 | c | 2 29 |
| | 29 | 220 10 | 7 35 | 14 41 | 31 | 18 20 | 37 | 13 | 17 0 | e | 2 58 |
| Aug | 8 | 212 35 | 8 3 | 14 10 | 32 | 17 43 | 40 | 14 | 14 2 | n | 3 20 |
| | 18 | 204 32 | 8 28 | 13 38 | 34 | 17 3 | 43 | 15 | 10 42 | d | 3 38 |
| | 28 | 196 4 | 8 47 | 13 4 | 35 | 16 20 | 44 | 18 | 7 4 | . | 3 50 |
| Sep | 7 | 187 17 | 8 50 | 12 29 | 35 | 15 36 | 44 | 22 | 3 14 | | 3 56 |
| | 17 | 178 27 | 8 53 | 11 54 | 36 | 14 52 | 45 | 25 | m 0 42 | D | +3 55 |
| | 27 | 169 34 | 8 49 | 11 18 | 35 | 14 7 | 43 | 28 | 4 37 | e | 3 50 |
| Oct | 7 | 160 45 | 8 39 | 10 43 | 34 | 13 24 | 43 | 30 | 8 27 | s | 3 37 |
| | 17 | 152 6 | 8 6 | 10 8 | 32 | 12 41 | 41 | 31 | 12 4 | c | 3 21 |
| | 27 | 144 0 | 7 37 | 9 36 | 30 | 12 0 | 38 | 31 | 15 25 | e | 2 54 |
| Nov | 6 | 136 23 | 6 29 | 9 6 | 26 | 11 22 | 33 | 30 | 18 19 | n | 2 20 |
| | 16 | 129 54 | 5 2 | 8 40 | 20 | 10 49 | 24 | 28 | 20 39 | d | 1 43 |
| | 26 | 124 53 | 2 52 | 8 20 | 12 | 10 25 | 15 | 24 | 22 22 | . | 0 58 |
| Dec | 6 | 122 1 | 0 43 | 8 8 | 3 | 10 10 | 3 | 19 | 23 20 | | 0 12 |
| | 16 | 121 18 | +1 49 | 8 5 | + 7 | 10 7 | + 9 | 14 | 23 32 | A | -0 34 |
| | 26 | 123 9 | 4 1 | 8 12 | 13 | 10 16 | 20 | 9 | 22 58 | s | 1 22 |
| Jan | 5 | 127 10 | 5 45 | 8 29 | 23 | 10 35 | 30 | 5 | 21 36 | c | 2 3 |
| | 15 | *132* 55 | 7 0 | 8 52 | 28 | 11 5 | 35 | 2 | 19 33 | e | 2 37 |
| | 25 | 139 58 | 7 57 | 9 20 | 32 | 11 40 | 40 | 0 | 16 *56* | n | 3 7 |
| Feb | 4 | 147 55 | 8 27 | 9 52 | 33 | 12 20 | 42 | 0 | 13 49 | d | 3 29 |
| | 14 | 156 22 | 8 41 | 10 25 | 35 | 13 2 | 44 | 1 | 10 20 | . | 3 45 |
| | 24 | 165 3 | . . | 11 0 | . | 13 46 | . | 3 | *6* 35 | | . . |

# Tables of Almanach: Sample

Vat.lat. 4572, 1r. Showing the first month-page in the tables, for March 1292, to illustrate §§26-31 in the canons. -- Three more samples of numbers, from single dates, are in *Appendix: Tables.*

<Mar>tius. -- Almanach planetarum ad annos domini 1292, motus octavae sphaerae 10 gra 1<5 m'a>.

| | Nume rus Die rum | Litt eræ Feri ales | Sol | Luna | Satur nus | Jupiter | Mars | Venus | Mercu rius | Caput | Lati tudo Lunæ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pisces | Leo | Aries | Leo | Sagit. | Pisces | Pisces | Leo | | |
| | | | Gr Mi | Gr Mi | Gr Mi | Gr Mi | Gr Mi | Gr Mi | Gr Mi | Gr Mi | Gr Mi | |
| | | | | | | Retro- | | | | | | |
| | 1 | d | 19 0 | 18 11 | 24 | 21 | 18 | 17 0 | 4 28 | 15 7 | 0 16 | Sep |
| | 2 | e | 19 59 | Vi 2 0 | 24 | 21 | 19 | 18 | 6 | 4 | 1 33 | Asc |
| | 3 | f | 20 59 | 15 27 | 24 | 21 | 20 | 19 | 8 | 15 0 | 2 32 | |
| Opp | 4 | g | 21 58 | 25 36 | 24 | 21 | 20 | 20 | 10 | 14 57 | 3 16 | |
| | 5 | a | 22 58 | Li 8 35 | 24 6 | 21 | 21 | 22 | 12 | 54 | 4 2 | |
| | 6 | b | 23 57 | 21 10 | 24 | 20 42 | 22 6 | 23 12 | 13 47 | 51 | 4 35 | |
| | 7 | c | 24 56 | Sc 3 49 | 24 | 21 | 22 | 24 | 15 | 48 | 4 54 | |
| | 8 | d | 25 56 | 16 2 | 24 | 21 | 23 | 25 | 17 | 45 | 5 0 | Dsc |
| | 9 | e | 26 55 | 28 2 | 24 | 20 | 23 | 27 | 19 | 41 | 4 52 | |
| | 10 | f | 27 54 | Sa10 8 | 25 | 20 | 24 | 28 | 21 | 38 | 4 31 | |
| | 11 | g | 28 53 | 22 34 | 25 | 20 | 25 | 29 27 | 23 17 | 35 | 3 56 | |
| | 12 | a | 29 52 | Ca 5 8 | 25 | 20 | 25 | Ar 1 | 25 | 32 | 3 11 | |
| | 13 | b | Ar 0 51 | 17 36 | 25 | 20 | 26 | 2 | 27 | 14 29 | 2 16 | |
| | 14 | c | 1 50 | 29 43 | 25 | 20 | 26 | 3 | 29 | 25 | 1 16 | |
| | 15 | d | 2 49 | Aq11 55 | 25 19 | 20 | 27 | 4 | Ar 1 | 22 | 0 13 | |
| | 16 | e | 3 48 | 24 21 | 25 | 19 53 | 27 42 | 5 39 | 2 48 | 19 | 0 52 | Mer |
| | 17 | f | 4 47 | Pi 7 3 | 25 | 20 | 28 | 7 | 4 | 16 | 1 56 | |
| | 18 | g | 5 46 | 20 2 | 26 | 20 | 29 | 8 | 6 | 13 | 2 55 | |
| Con | 19 | a | 6 45 | Ar 0 8 | 26 | 20 | 29 | 9 | 8 | 10 | 3 36 | |
| | 20 | b | 7 44 | 13 35 | 26 | 20 | Ca 0 | 10 | 10 | 6 | 4 18 | |
| | 21 | c | 8 43 | 27 19 | 26 | 20 | 1 | 11 51 | 12 17 | 3 | 4 47 | |
| | 22 | d | 9 42 | Ta11 28 | 26 | 20 | 1 | 13 | 14 | 14 0 | 5 0 | |
| | 23 | e | 10 41 | 25 58 | 26 | 19 | 2 | 14 | 16 | 13 57 | 4 53 | Asc |
| | 24 | f | 11 40 | Ge10 48 | 26 | 19 | 2 | 15 | 18 | 54 | 4 27 | |
| | 25 | g | 12 39 | 25 29 | 26 35 | 19 | 3 | 17 | 20 | 51 | 3 44 | |
| | 26 | a | 13 38 | Ca 9 39 | 27 | 19 21 | 3 26 | 18 4 | 21 33 | 47 | 2 48 | |
| | 27 | b | 14 36 | 23 32 | 27 | 19 | 4 | 19 | 23 | 44 | 1 43 | |
| | 28 | c | 15 35 | Le 7 24 | 27 | 19 | 5 | 20 | 25 | 41 | 0 33 | |
| | 29 | d | 16 34 | 21 30 | 27 | 19 | 5 | 21 | 27 | 38 | 0 41 | Sep |
| | 30 | e | 17 32 | Vi 5 17 | 27 | 19 | 6 | 23 | 29 | 35 | 1 50 | |
| | 31 | f | 18 30 | 18 41 | 27 | 19 | 6 | 24 13 | Ta 0 33? | 13 31 | 2 53 | |
| | | | | | | -gradus | | | | | | |

| | Tempus | Medius Lunae | Argumentum Lunae | But Solis | But Lunae |
|---|---|---|---|---|---|
| | Di Ho Mi | Si Gr Mi | Si Gr Mi | Mi 2a | Mi 2a |
| Media coniunctio(!) | 4 13 21 | 5 10 19 | 8 27 13 | 2 28 | 32 49 |
| Media oppositio(!) | 19 7 43 | 11 24 52 | 3 10 7 | 2 27 | 31 49 |

(*Horoscope diagram, in centre:*) Tempus verae o<ppositionis> praecedentis <introitum> solis in Arietem: 4 dies 7 horae 25(?) m'a Martii. / In hac figura Saturnus est potentior. (*Horoscope diagram, in the 12 cells around the edges:*) Saturnus 24; 9 Arietis -- 12 Tauri -- 14 Gemini -- 12 Cancri -- Jupiter 21 Leonis; Caput 15; 8 Leonis -- 8 Virginis; Luna 23 -- 9 Librae -- 12 Scorpii -- 14 Sagitt.; Ma<rs> 20 -- 12 Capricor. -- 8(?) Aquarii; Cauda 15 -- Sol 23 Piscium; Venus 20; Mercurius 10; 8(?) Piscium.

# Tables: Manuscripts

There are two known manuscripts:

**Vat.:** Vat.lat. 4572, 1r-102v. -- Covers 1292-1304 and 1309.

Several glossator hands, all no doubt contemporary:
**(m1)**: notes in common with P, and some more notes.
**(m2)**: For 1292: Perhaps all the notes, including one eclipse prediction and two observations. For 1293: addition to (m1), 11v, July; and 14v, October; observations in both cases. -- No instances after 1293.
**(m3)**: personal names, some with "nativitas" or "fratris" added: 10v, 11v, 39v, 51r, 63v.

**Par.:** Par.lat. 16201, 2r-229v. -- Covers 1292 Feb (last month of the year; astrology page only), and 1293-1311.

I cannot distinguish between glossator hands, except that the first and second gloss on 2r and the gloss on 222v are probably each in their own foreign hand. -- There are notes on correction at bottoms of last (February) pages at: 13v, 14r (1293, "cor", "correctus"), 49v (1296, "correptum est"), 121v, 133v, 145v, 157v, 169v, 181v, 193v, 205v, 217v (1302-1310, all "correctus").

Both manuscripts contain astrology pages for February 1292 - January 1295, concerning planetary aspects; see below, gloss to Par.lat. 16201, 2r. They are not mentioned in the canons. -- In Par., the part covering 1292 is missing except for the last page, namely, the astrology page for February "1292", so it is not known whether there were more such in this part. In any case both sets of astrology pages stop in January 1295, so it is likely that they never went any further. -- In Par. the missing astrology pages are blank; in Vat. they are left out.

If anything, it is likely that Vat. is an apograph of Par. (in a state in which it had not yet lost the pages for AD 1292) by someone who decided to eliminate the blank astrology pages. Cf. also the second note for July 1293, which is within a horoscope diagram (otherwise blank) in

Par. but not in Vat. On the other hand, Vat. has been in the possession of somebody (perhaps William himself) who decided to add his own observations, cf. most conspicuously the gloss to July 1293 reproduced in the next section.

The eclipse predictions do not go beyond 1295 in Vat. or in Par. (except for one for 1311 in Par., located at Saint-Quentin, no doubt by a foreign user). Possibly they were work in progress, as were the astrology pages; cf. canons §30 "Nihilominus tamen *intendo* per totum almanach notare tempora et quantitates eclipsium tam solis quam lunae." -- In general, there are no glosses after 1295, except the m3-notes in Vat. and the stray one for 1311 in Par.

The non-rounded values for Saturn are curiously out of phase with those for the four other planets. In fact, for Saturn they start on March 5, 1292, and continue at 10-day intervals throughout the almanach. The values for the other planets appear calculated on a 4-year basis. Indeed, in the first month (March) of the years 1292, 1296, 1300, 1304 and 1308, where the preceding February is bissextile, Jupiter and Mars have their first non-rounded values on March 6, and Venus and Mercury on March 1. These values fall at an interval of 11 days, respectively 6 days, after the preceding non-rounded values, or in other words, one day later than expected from the normal 10-day or 5-day intervals. In this way the Saturn values appear to fall behind the rest, by 1 day for 1292-95 (as is seen in the sample above) and up to 5 days for 1308-11. I do not know what method lies behind this, and the canons and glosses give no hints.

# Tables: Glosses

"+V" and "-V" means "present in Vat." and "absent in Vat.", respectively.

"+P" and "-P" means "present in Par." and "absent in Par.", respectively.

If a month is cited, e.g. "1292 May", the gloss is generally in the lower margin of the month in question. If a day is cited, e.g. "1292 July 30", the gloss is generally in the right or left margin opposite the date in question.

**Bold type** is used for text common to the two manuscripts.

## Glosses, etc., in Vat. lat. 4572:

Vat., 1r-7r: whole of year 1292 (including 1 page of astrology, namely, 7r, for February "1292")

(Vat., 1r, 1292 March, cf. Canons §26-27:) (m2?) In toto almanach est notandum quod luna est aequata ad horas mediae coniunctionis et oppositionis, et in diebus inter coniunctionem et oppositionem est aequata ad horam similem horae coniunctionis, et in diebus inter oppositionem et coniunctionem est aequata ad horam similem horae oppositionis. Et inde accidit quod duae aequationes lunae aliquando cadunt in directo eiusdem diei, eo quod coniunctio et oppositio cadunt inter duas meridies; quarum unam oportet ponere extra, ut apparet in 17'a die Aprilis.

(Vat., 2r, 1292 May, cf. Canons §28:) (m2?) Per totum \ubi/ ponitur medius motus lunae \est/ in octava sphaera; quem si velis habere in nona sphaera, adde sibi motum octavae sphaerae, quem invenies in mense Martii.

(ibid., m2?) Buth idem est quod motus aequatus in una hora, tam in sole quam in luna.

(Vat., 3r, 1292 July 30:) (m2?) Eclypsis.

(Vat., 3r, 1292 July:)(m2?) Per 7 horas et 27 mi'a horae post meridiem 30'ae diei huius mensis, quae erit dies Mercurii ante festum beati Petri ad vincula, erit vera oppositio solis et lunae, et eclipsabitur de luna circiter medietas, et incipiet sub terra et terminabitur super terram; et erit pars eclipsata versus septentrionem, quia argumentum latitudinis secundo aequatum erit .6. 8. (!) gra et 6 m'a etc.

(Vat., 5v, 1292 December:)(m??) Tempus verae coniunctionis Decembris 9 dies 21 hora 58 m'a, ascendens primus gradus aquarii. Tempus verae oppositionis 25 dies nulla hora 9 m'a, ascendens primus gradus tauri.

(Vat., 6r, "1292" January:)(m2) Die sabbati post Epiphaniam Domini vidi Venerem et Mercurium ante ortum solis, et erat Venus septentrionalis ab eo plus quinque gradibus. Mercurius etiam latitudinem septentrionalem habebat plus quinque gradibus. Et per hoc videtur quod latitudo Veneris tunc esset in septentrionem plus decem gradibus; et hoc ita invenitur per tabulas bipartialis numeri et quadripartialis.

(Vat., 6v, "1292" February:)(m2) Die Mercurii post Purificationem beatae Mariae virginis vidi lunam cum Venere sub altitudine Alchimech 16 grad<uum> a parte occidentis, et erant illa hora in eodem azimuth, et erat Venus septentrionalior luna plus quinque gradibus; luna etiam latitudinem septentrionalem habebat.

(Vat., 10v, 1293 June 11:)(m3)(-P) <--?> Andrea. Hic.

(Vat., 11v, 1293 July:) (m1)(+P) **Quinta die[i] Iulii** quasi **per** \duas horas/ **cum dimidia ante meridiem erit eclipsis solis particularis quasi tertia pars.** (m2)(-P) Incepit sub ascendente 15 gra virginis, ut credo, et eclipsata fuit pars meridiana circiter tertia pars diametri.

(ibid., m1)(+P) **Tempus verae coniunctionis 4 dies 22 horae** 49 **minuta Iulii.**

(Vat., 11v, 1293 July 14-15:)(m3?)(-P) Luti (*or* Luci)

(Vat., 13v, 1293 September, approx. opposite day 3:)(m??)(-P) <--> libre ven(er)it .p.J.(?) et pi(?) nouis<-->s(?) positus est cant(us)

(Vat., 14v, 1293 October:)(m2)(-P) <29'a(?)> die huius mensis, quae fuit dies Iovis, ante ortum solis quasi per unam horam, vidi Martem cum Iove, et erat adhuc Mars retro Iovem et meridiona<li>or ipso quasi per

10 m'a. In crastino autem simili hora vidi adhuc eos, et transiverat Mars Iovem plus quam distaret retro die <prae>cedenti.

(Vat., 14v, 1293 Oct 29:)(m1?)(-P) <-->s et Martis.

(Vat., 14v, lower edge of page, partly cut away:)(m1?)(-P) <-->'a huius(?) mensis sub altitudine solis 9(?) g(ra) d<-->

(Vat., 16v, 1293 Dec 14:)(m1)(+P) **Eclipsis particularis quasi tertia pars**.

(ibid., 1293 Dec, lower mg.:)(m1)(+P) **Per 14 horas et 59 m'a horae post meridiem 14'ae diei huius mensis, quae erit dies lunae post festum sanctae [[--]] Luciae, erit eclipsis lunae circa tertiam partem.**

(ibid., 1293 Dec, lower edge, partly cut away:)(m1)(+P) **Tempus verae oppositionis 14 dies <-->**

(Vat., 22v, 1294 June 9:)(m1)(+P) **<Ecl>ipsis sub terra.**

(Vat., 28v, 1294 Dec 3:)(m1)(+P) **Eclipsis lunae sub terra.**

(Vat., 33v, 1295 May:)(m1)(+P) **Per 12 horas et 39 m'a post meridiem 29'ae diei huius mensis erit eclipsis lunae totalis et etiam cum mora, et hoc erit nocte sequente diem dominicam post festum Urbani; 39 minutis horae post mediam noctem** erit medium eclipsis, **et incipiet ante mediam noctem quasi per horam unam.**

(Vat., 39v, 1295 Nov 8:)(m1)(cf.P) **<?> eclipsis solis.**

(Vat., 39v, 1295 Nov 29-30)(m3)(-P) Nativitas a(n).dree fra(tris)

(Vat., 51r, 1297 July 12:)(m3:)(-P) Nativitas Gerardi fra(tris) ho(ra) .ii. as(cendente) cap(r)i(corno)

(Vat., 63v, 1299 August 6, m3:) Hic nativitas Galeot et Bogani

Vat. 91r: start of 1304, *motus 8ae sphaerae* 10;26 (1303 was at 85r, *motus* 10;25). There is no discontinuity in Jupiter's positions within the year "1304". The year ends normally with February on 96v.

Vat. 97r: jumping to "1309", *motus* 10;30, and Jupiter's position jumps too.The manuscript ends on 102v with "Februarius" (still 1309, no jump in Jupiter's position during this year).

## Glosses, etc., in Par. lat. 16201:

Par, 2r: astrology page for February "1292", which is the last month of the year. Apart from this, the pages for 1292 are missing.

(Par,2r, 1292 February:)(-V) Figurae planetarum, Solis ... Figurae aspectuum, Coniunctio ... Caput draconis ... Cauda draconis ...

(Par,2r)(-V) In prima columna sunt aspectus lunae ad planetas et numerus horarum ante meridiem illius diei in directo cuius scribuntur. In secunda columna sunt aspectus lunae ad planetas et numerus horarum post meridiem. In tertia columna sunt aspectus planetarum adinvicem, sed non est ibi numerus horarum, quia in coniunctione planetarum sufficit habere diem.

(Par, 6v, 1293 July:)(+V) **Quinta die Iulii per** horam **cum dimidia ante meridiem erit eclipsis solis particularis quasi tertia pars.**

(Par, 6v, in centre of a horoscope diagram, which is otherwise blank:)(+V) **Tempus verae coniunctionis 4 dies 22 horae** 52 **minuta Iulii.**

(Par, 11v, 1293 December 14:)(+V) **Eclipsis lunae particularis quasi tertia pars.**

(Par, 11v, 1293 December:)(+V) **Per 14 horas et 59 m'a horae post meridiem 14'ae diei huius mensis, quae erit dies lunae post festum sanctae Luciae, erit eclipsis lunae circa tertiam partem.** etc.

(Par, 11v, 1293 December, lower edge of page:)(+V) **Tempus verae oppositionis 14 dies** 14 horae 55 mi'ta Decembris.

(Par, 17v, 1294 June 9-10:)(+V) **Eclipsis** lunae **sub terra.**

(Par, 23v, 1294 December 3-4:)(+V) **Eclipsis lunae sub terra.**

(Par, 28v, 1295 May 29:)(-V) Eclipsis lunae.

(Par, 28v, 1295 May:)(+V) **Per 12 horas et 39 m'a post meridiem 29'ae diei huius mensis erit eclipsis lunae totalis et etiam cum mora, et hoc erit nocte sequente diem dominicam post festum Urbani, 39 minutis**

**horae post mediam noctem, et incipiet ante mediam noctem quasi per unam horam.**

(Par, 34v, 1295 Nov 8:)(+V) **Eclipsis solis post meridiem octavae diei.**

(Par, 34v, 1295 Nov 22-23:)(-V) Eclipsis lunae sub terra.

(Par, 34v, 1295 November:)(-V) In ista coniunctione eclipsabitur sol in parte. Tempus verae coniunctionis 2 horae 34 m'a post meridiem 8'ae diei.

(Par, 222v, 1311 July:) <Anno domin>i 1311 16 die Iulii super A litteram, 17 Kls. Augusti, eclipsabuntur de diametro solis <11 dig>iti et 30 mi'a; totus fere sol eclipsabitur praeter vicesimam quartam partem. Et durabit eclipsis <-- hor>is et duobus minutis apud Sanctum Quintinum. Initium eclipsis una hora 53 minutis ante occasum <solis apud> Sanctum Quintinum.

# Appendix

Contains the slightly edited worksheets for my (manual) recomputations of values in the canons and the tables of the Almanach. They mostly concern longitudes, computed from the Toulouse Tables.

## The Toulouse Tables

Mean motion calculations rest on the Toulouse mean motion tables in ms. Par.lat. 16658. Toulouse is on longitude 1°27' E, thus 53' to the west of Paris, and the Toulouse Tables were commonly used for Paris without correction. The mean motion values have been checked for consistency with their neighbouring tabular values, and have been collated with the recomputation printed by Poulle, 1994, and with the Toledan mean motion tables (Pedersen 2002) as concerns the day- and minute-values.

Planetary equations are taken from the Toledan tables as found in Pedersen 2002; table designations like "EA41" refer to this work. These equations would be the same as those used by William. As used here, they incorporate the scribal errors normally found in vulgate Toledan collections, as reflected by the edition just mentioned. It is not certain that William's source showed the same errors, but any deviations are likely not to have exceeded a few minutes of arc.

There are also likely to be errors due to rounding and, e.g., to the granularity of the minutes of proportion, which I have everywhere treated as integers; on the other hand, because I have availed myself of Benno van Dalen's sexagesimal calculator, I may occasionally have used more precise values than William intended. -- Quite a few deviations (example statistics, see *Appendix: Tables*, below) are, however, not explicable on any of these accounts, and must be due to errors either on my part or on William's. I can only say I have taken some pains in checking my calculations.

No account has been taken of the equation of time, which in this text (cf. §29 at end, conforming to the Toledan Tables) should always be added to the mean solar time to get the true solar time. It varies between +0m and +31m, cf. the table §47. This ought to mean that the tabular mean solar time should be some 16m less than the modern one, but this has been disregarded.

The mean motions, and thus the calculated "true places", are sidereal, which is here expressed as "for the eighth sphere"; to make them comparable with the tropical longitudes in William's Almanach tables and in modern ephemerides, one should add "the motion of the eighth sphere" (see §2-6). This is analogous to the precession but with an origin in time close to AD 600.

In the Toulouse mean motion tables, as in the *Almanach*, the year begins with March. Table lookup is always done with elapsed years, months, etc.; thus, 1290 "March 3" should be looked up as 1272years + 17years + no months + 2days. However, according to the convention of the Toulouse Tables, "March 3" begins at noon on our March 2 (cf. §26); so in order to advance the time to noon on our March 3 (as is general in the *Almanach*, see below), an extra day should be counted in.

William's own time indications are more like the civil ones, since he departs from the daylight period and describes the time of night as being before or after this period (ambiguity only in §11). This also holds for the tables of the *Almanach*: thus the values given for, e.g., March 3 are valid for the noon belonging to the daylight period which we call "March 3" (cf. §26). In the notes to the translation, the modern time-of-day convention is followed.

## Rules for calculation of planetary longitudes

The rules William used were like those in the Canons "Cb" to the Toledan Tables, as printed in F.S. Pedersen 2002, vol. 2 p. 435-441. I reproduce the translation here. The variable names used in the calculations below are meant to correspond with this translation.

**(Cb141a)** Equating the motion of the sun.

If you want to equate the place of the sun, obtain its mean motion in the way shown before (cf. CA01), and having found it, put it down in two places, and keep one of them untouched. But from the other one, subtract the apogee of the sun (DA01), that is, 2 signs 17 degrees 50 minutes, if you can; but if not, add 12 signs to the mean motion and subtract the said apogee from the resulting number; and the remainder will be the "argument" of the sun. – **(Cb141b)** With this, enter the columns of numbers (EA01), and write out the solar equation you find opposite it; and you should add this to the solar mean motion which was kept untouched, if the argument is greater than 6 signs, or subtract it if the argument is less than 6 signs. – **(Cb142)** But if there are minutes together with the argument, you are to enter [the table] with it a second time, adding 1 degree to it [that is, to the argument]; and write the corresponding equation below the first equation. Then consider the difference between the two equations, [that is, subtracting the smaller equation from the larger, and the remainder will be the difference,] and of this, take a portion whose ratio to the entire difference is as the ratio of the minutes in the argument to 60, [by means of denomination, or multiplication and division, or tables made for the purpose;] and add this <portion> to the first equation if it is less than the second one, or subtract the portion from it if it is greater than the second one. Or, if you want to, multiply the minutes in the argument by the entire difference, [having reduced either to its lowest denomination,] [and then divide by 60,] and add the resulting degrees, minutes and seconds to the first equation if it is less, as was said, or subtract them if it is greater. Then add <the equation> to the mean motion of the sun, if the argument is greater than 6 signs, or subtract it if <the argument is> less, as has been indicated before; and then you will get the true place of the sun, and this is reckoned from the beginning of Aries [in the eighth sphere. To this true place, add the place of the eighth sphere, and you will get the truer place; and this is done in the case of the other planets too.]

**(Cb143)** On finding the true place of the moon.

If you want to find the true place of the moon, take its mean motion and <mean> argument, that is, each of them separately, from the tables (CA11, CA21), in the same way as is done for the sun. Then subtract the mean motion of the sun from the mean motion of the moon, and by doubling the remainder you will get the centrum of the moon, which is called the "double elongation" [which is termed centrum of the moon]. With this, enter the columns of numbers (EA11), and write down apart the "equation of centrum" and "minutes of proportion" that are opposite it, taking each of them separately. Then consider the centrum of the moon; if this is less than 6 signs, add the equation of centrum to the argument of the moon; but if it is greater, subtract that equation from the argument. And in this way you will correct the argument, [and this will be called the "corrected argument".]

So, with this, [that is, with the corrected argument,] enter the columns of numbers of <the table of equation of> the moon, and take down what you find opposite it concerning the equation of argument and the "equation of variation of the diameter of the small circle of the moon" — also called the epicycle — each of them separately. Then, of the "variation of the diameter", take a portion whose ratio to the total "variation" is as the ratio of the minutes of proportion to 60, and add this to the equation of argument of the moon. Having been corrected in this way, the equation of argument should be added to the mean motion of the moon — which was earlier taken from the tables and was kept untouched — if the argument is greater than 6 signs, or it should be subtracted if <the argument> is less than 6 signs; and the remainder will be the true place of the moon, and it will be reckoned from Aries, as was said before concerning the sun.

**(Cb144)** On the ascending node.

Find the motion of the ascending node (CA31) in the same way as for the sun; and subtracting this from 12 signs, you will find the place <of the node>. For the remainder from the subtraction of the mean motion from 12 signs will be the true place of the ascending node; this is reckoned from Aries, as <is the case for> all the planets.

**(Cb145)** On equating the three upper planets.

When you want to equate any of the three upper planet to the sight, find the mean motion of any of them (CA41-61) and subtract it from the mean motion of the sun; and keep the remainder, <to serve> for the "argument" of the given planet. Also, subtract the apogee of the planet (DA4*-6*) from its mean motion, and the remainder from this will be the "centrum" of the planet; and put it below the argument. – **(Cb146)** So, with the said centrum, enter the columns of numbers for <the equation of> the planet (EA41-61), and take down separately, below the centrum, the equation of centrum which you find opposite it. And write "Add" above it, if the centrum is greater than 6 signs, and add it to the centrum and subtract it from the argument; but if the centrum is less than 6 signs, write "Subtract" above the equation <of centrum>, and subtract it from the centrum and add it to the argument; and in this way you will get both the corrected centrum and the corrected argument. So enter the columns of numbers for the second time with the said corrected centrum, and note down the minutes of proportion you find opposite it, separately at the bottom. – **(Cb147)** Also, enter the same columns with the corrected argument, and write, separately, each of the corresponding <values for> the "equation of argument" and for the "variation of epicyclic diameter" in one of the distances; for you will take it in <the sub-table for> the "far distance", if the centrum – before correction – is from 1 degree to 3 signs or from 9 signs to 12; but if it is from 3 to 9, take it in <the sub-table for> the "near distance". Of this "variation," take a portion according to the ratio of the minutes of proportion to 60, by denomination or by multiplication as we explained in <the case of> the sun. Add this portion to the equation of argument if <the "variation"> belongs to the near distance, or subtract it if it belongs to the far distance; and the remainder will be the equation of argument, corrected by means of the variation of epicyclic diameter. Write "Add" above this if the <corrected> argument <you looked it up with> is less than 6 signs, or "Subtract" if it is greater. – **(Cb148)** Then consider the said equation of argument, and the equation of centrum; if "Add" is written above both, add them together and add <the sum> to the mean motion of the planet; and if "Subtract" is written <above both>, subtract <their sum> from the mean motion of the planet. But if "Subtract" is written above one and "Add" above the other, subtract the smaller from the larger; and if the remainder <is part of the equation that> has the heading "Subtract", then subtract it from – or if it <is part of the one that>

has the heading "Add", then add it to – the mean motion of the planet that was found before and was kept untouched. And this, after the addition or subtraction, will be the truest place of the planet.

**(Cb149)** Equating Venus and Mercury.

Equating Venus and Mercury is like equating the three upper planets, **(Cb150)** except that, for the present planets, the arguments are found from tables (CA71-81) whereas the mean motion is the same as the mean motion of the sun. – **(Cb151)** There is, however, a difference concerning the minutes of proportion of Mercury (EA81.Pro): for <in this case> we are to find whether <the portion of> the "variation of diameter" is to be added to or subtracted from the equation of argument, by considering the heading of the minutes of proportion. For if "Subtract" is written there, we subtract the said variation, but if "Add", we add it; and we do not take into account whether the variation belongs to the far or the near distance, as is done concerning the other planets.

# Appendix: Canons

The paragraph numbers refer to the text and the translation of the canons. The results of the calculations listed here are summarized in the footnotes to the translation.

The checkmark * for mean motion values means that they are taken from Par. lat. 16658, and checked from Poulle 1994 (for values down to months) or from Toledan Tables in Pedersen 2002 (for values from days downwards).

The checkmark = normally means that a value has been checked in two different ways. Check marks are, however, not used consistently.

## §2

```
Motion of the eighth sphere, according to Thebit's tables, said
to be 9°23' for AD 1292.

Mean motion of 8th sphere from: TT p.1547, PA21 (Toulouse tables)

AD 1272:   1s 29;18, 7,25°
19 years:  0s  1;41, 9,51   # giving 61° for AD 1291 elapsed =
                            # 1292 current

Equation of 8th sphere from: TT p.1554, PB11 (same values as TT
p.1562, PB11f, in Toulouse Tables):

60°:       9;17,44°
65°:       9;43,53°
------------------
Diff. 5°   0;26, 9°

Diff. 1°   0; 5,14°

61°:       9;22,58°  # perfect fit to 9;23°, look no further
```

## §5

```
Longitude of Sun according to Toulouse Tables, for 1290 March 12
+ 16 hours.
```

```
Said to be 11s 19;47 in 8th sphere.


Mean motion of Sun, ms. P = Par.lat.16658, 70r-v:

1272a:     11  5 40 13*
17a:       11 29 38 39*
March        (nothing)*
12d:        0 11 49 38*
16h:        0  0 39 25*
--------
Mean:       11 17 47 55

Apogee      2 17 50 10    # DA02.

Argt:       8 29 57 45    # Mean motion minus apogee
                          # (always minus, Cb141a)

Eqn:           1 59 10    # EA01; eqn to be added
                          # since argt > 6s, Cb141b
--------
True:      11 19 47  5    # OK


Time thus: 1272 + 17 yrs elapsed, 0 months, 12d + 16h elapsed.

So the noon in question was indeed the one at the end of the
astronomical day March 12th, or, "noon of March 12" in common
parlance.
```

# §10

```
40 minutes of time difference for conjunctions and oppositions
corresponds to 22 minutes of arc in lunar mean motion:

# Toulouse table Par.lat. 16658, 71v: 40m -> 0;21,57,20°  # OK
```

# §11

```
The calculations for the following paragraphs (§11, sections
concerning 1285 Dec 31 and Dec 16) have been checked again. The
mean motions are in order, and I think the equations are too. The
corrections were done on paper, so there are no checkmarks.
```

# §11: 1285 Dec 31

<In 1285 imperf., on 31 Dec> according to Toulouse Tables, Jupiter would be ahead of Saturn by more than two degrees.

SUN, mean motus for 1285 Dec 31, noon (lookup: 1284y elapsed + November elapsed + 31d), Toulouse tables, Par.lat. 16658, 70r-v:

```
# Might as well have used "December elapsed" plus nothing; this
is "10 1 35 46", as it should be.

1272a:          11  5 40 13*
12a:            11 29 55 22*    # "55": for the
                                # reading "58" in Par.lat.16658
Nov:             9  1  2 33*
30d:             0 29 34  5*
1d:              0  0 59  8*
--------
Mean Motus:      9  7 11 21
```

---- SATURN, 1285 Dec 31, noon

Saturn for 1284y elapsed + November elapsed + 31d, Toulouse tables, Par.lat. 16658, 74r-v:

```
1272a:           4 28 11  1*
12a:             4 26 38 23*
Nov:             0  9 12  2*
30d:                1  0 13*
1d:                 0  2  0*
--------
Mean motus:     10  5  3 39

Argument:       11  2  7 42   # mean motus Sun
                              #  - mean motus Saturn

Apogee:          8  0  5  0

Centrum:         2  4 58 39   # mean motus Saturn - apogee

                  SUBTRACT    # because centrum < 6s
Eqn of centrum:     5 47      # EA41.Ece (centrum = 2s5°)

Corr. centrum    1 29 12      # centrum - eqn.c.
                              # (minus as centrum <6s)
```

```
Corr. argt      11  7 55       # argt + eqn.c.
                               # (plus as centrum <6s)

Min. prop.            30       # EA41.Pro (corr. centrum = 1s29°)

Eqn of argt         2  8       # EA41.Ear (corr. argt = 11s7;55°)

Var. diam. FD       0  6       # EA41.Dlo
                               # (corr. argt= 11s7;55;
                               # Far Distance as 0s<centrum<3s)

portion var diam.   0  3       # Var.diam. * Min.prop. / 60

                  SUBTRACT     # because corr. argt > 6s
Corr. eqn.argt.     2  5       # eqn argt - portion var.diam.
                               # (minus as Far Dist.)

Sum                 7 52       # eqn of centrum + corr. eqn. argt


True place       9 27 12       # mean motus - Sum
                               # (subtract as twice SUBTRACT)




---- JUPITER, 1285 Dec 31, noon


Jupiter for 1284y elapsed + November elapsed + 31d, Toulouse
tables, Par.lat. 16658, 75r-v:

1272a:           9  7 10 57*
12a:             0  4 11 13*
Nov:             0 22 51  0*
30d:                2 29 34*
1d:                 0  4 59*
--------
Mean motus:     10  6 47 43


Argument:       11  0 23 38    # mean motus Sun
                               #  - mean motus Jupiter

Apogee:          5 14 30 0     # OK for Jupiter

Centrum:         4 22 17 43    # mean motus Jupiter - apogee

                  SUBTRACT     # because centrum < 6s
Eqn of centrum:     3 20       # EA51.Ece (centrum = 4s22;17,43°)

Corr. centrum    4 18 58       # centrum - eqn.c.
```

```
Corr. argt      11  3 44      # argt + eqn.c.

Min. prop.            46      # EA51.Pro (corr. centrum = 4s19°)

Eqn of argt         4  8      # EA51.Ear (corr. argt = 11s3;44°)

Var. diam. ND       0 10      # EA41.Dpr
                              #(corr. argt= 11s3;44;
                              # Near Dist. as 3s<centrum<9s)

portion var diam.   0  8      # Var.diam. * Min.prop. / 60

                  SUBTRACT    # because corr. argt > 6s
Corr. eqn.argt.     4 16      # eqn argt + portion var.diam.
                              # (plus as Near Dist.)

Sum                 7 36      # eqn of centrum + corr. eqn. argt

True place        9 29 12     # mean motus - Sum
                              # (subtract as twice SUBTRACT)

----

True place Saturn acc. to Toulouse: 9s 27;12

True place Jupiter acc. to Toulouse 9s 29;12

# Difference 2;0°. Thus the "more than two degrees" is not quite
reproduced. Then again, the comparable time is "after sunset",
which would be 4-5h later, corresponding to some 1½' above the 2°
in elongation (for the daily increment in elongation between
Saturn and Jupiter, of about 7', see next section).
```

## §11: 1285 Dec 16

Concerning 1285 Dec 16, i.e. "15 days" before Dec 31, for which see above.

<In 1285 imperf., on 31 Dec> according to Toulouse Tables, Jupiter would be ahead of Saturn by more than two degrees, "and thus, from the tables, they were found to be in conjunction more than 15 days before they really were."

Trying 1285 Dec 16, noon.

SUN, mean motus for 1284y elapsed + November elapsed + 16d, Toulouse tables, Par.lat. 16658, 70r-v:

```
1272a:          11  5 40 13*
12a:            11 29 55 22*   # "55" for the "58" of ms.
Nov:             9  1  2 33*
16d:             0 15 46 11*
--------
Mean motus:      8 22 24 19


---- SATURN for 1285 Dec 16, noon

Saturn for 1284y elapsed + November elapsed + 16d, Toulouse
tables, Par.lat. 16658, 74r-v:

1272a:           4 28 11  1*
12a:             4 26 38 23*
Nov:             0  9 12  2*
16d:                0 32  7*
--------
Mean motus:     10  4 33 33

Argument:       10 17 50 46    # mean motus Sun
                               #  - mean motus Saturn

Apogee:          8  0  5  0    # OK Saturn

Centrum:         2  4 28 33    # mean motus Saturn - apogee

                  SUBTRACT     # because centrum < 6s
Eqn of centrum:     5 45       # EA41.Ece (centrum = 2s4;28,33°)

Corr. centrum    1 28 44       # centrum - eqn.c.
                               # (minus as centrum <6s)

Corr. argt      10 23 36       # argt + eqn.c.
                               # (plus as centrum <6s)

Min. prop.            30       # EA41.Pro
                               # (corr. centrum = 1s28;44°)

Eqn of argt         3 22       # EA41.Ear
                               # (corr. argt = 10s 23;36°)

Var. diam. FD       0 10       # EA41.Dlo
                               # (corr. argt= 10s23;36;
                               # Far Dist. as 0s<centrum<3s)

portion var diam.   0  5       # Var.diam. * Min.prop. / 60

                  SUBTRACT     # because corr. argt > 6s
Corr. eqn.argt.     3 17       # eqn argt - portion var.diam.
                               # (minus as Far Dist.)
```

```
Sum                   9  2      # eqn of centrum + corr. eqn. argt


True place 8th    9 25 32       # mean motus - Sum
                                # (subtract as twice SUBTRACT)




---- JUPITER, 1285 Dec 16, noon


Jupiter for 1284y elapsed + November elapsed + 16d, Toulouse
tables, Par.lat. 16658, 75r-v:

1272a:            9  7 10 57*
12a:              0  4 11 13*
Nov:              0 22 51  0*
16d:                 1 19 46*
--------
Mean motus:      10  5 32 56


Argument:        10 16 51 23    # mean motus Sun
                                #  - mean motus Jupiter

Apogee:           5 14 30  0    # OK for Jupiter

Centrum:          4 21  2 56    # mean motus Jupiter - apogee

                  SUBTRACT      # because centrum < 6s
Eqn of centrum:     3 25        # EA51.Ece (centrum = 4s21;3°)

Corr. centrum     4 17 38       # centrum - eqn.c.
                                # (minus as centrum <6s)

Corr. argt       10 20 16       # argt + eqn.c. (plus as ditto)

Min. prop.            46        # EA51.Pro
                                # (corr. centrum = 4s17;38°)

Eqn of argt         6  7        # EA51.Ear (corr. argt = 10s20;16°)

Var. diam. ND       0 15        # EA51.Dpr (corr. argt= 10s20;16;
                                # Near Dist. as 3s<centrum<9s)

portion var diam.   0 11        # Var.diam. * Min.prop. / 60

                  SUBTRACT      # because corr. argt > 6s
Corr. eqn.argt.     6 18        # eqn argt + portion var.diam.
                                # (plus as Near Dist.)

Sum                 9 43        # eqn of centrum + corr. eqn. argt
```

```
True place 8th   9 25 50       # mean motus - Sum
                               # (subtract as twice SUBTRACT)

----

Thus:

16 Dec:       Saturn 9s 25 32   Jupiter 9s 25 50    elong 0;18
31 Dec:       Saturn 9s 27 12   Jupiter 9s 29 12    elong 2; 0

15 days       Saturn     1 40   Jupiter     3 22

Motions during 1 day:
Saturn   0; 6,40 = 0.111 (0.113 Tuck)
Jupiter  0;13,28 = 0.224 (0.229 Tuck)
```

Velocity diff = 0;6,48 (as neither is retrograde), so the elongation of 0;18 corresponds to 2;39 days. So on this account, the conjunction occurred more than 17 days before Dec 31. How William got his "more than 15 days" is hard to say, but the correspondence may be thought satisfactory.

## **§12:** 1285 Dec 31 (mean motions corrected)

Would William's mean motus corrections (namely, -1° for Jupiter and +1;15° for Saturn) mean that the conjunction would turn out to fall on 1285 Dec 31?

Time of day is set to noon, arbitrarily.

```
---- SUN, mean motus for 1285 Dec 31, noon:

Unchanged        9  7 11 21   # from above, Dec 31



---- SATURN, 1285 Dec 31, noon; mean motus corrected by +1;15°:

Mean motus      10  6 19       # i.e., 10s5;3,39° plus 1;15°

Argument:       11  0 52       # mean motus Sun
                               # - mean motus Saturn

Apogee:          8  0  5  0
```

```
Centrum:          2  6 14      # mean motus Saturn - apogee

                   SUBTRACT    # because centrum < 6s
Eqn of centrum:      5 51      # EA41.Ece (centrum = 2s6;14°)

Corr. centrum     2  0 23      # centrum - eqn.c.
                               # (minus as centrum <6s)

Corr. argt       11  6 43      # argt + eqn.c. (plus as centrum
<6s)

Min. prop.             30      # EA41.Pro
                               # (corr. centrum = 2s0;23°)

Eqn of argt          2 14      # EA41.Ear (corr. argt = 11s6;43°)

Var. diam. FD        0  7      # EA41.Dlo (corr. argt= 11s6;43;
                               # Far Dist. as 0s<centrum<3s)

portion var diam.    0  3      # Var.diam. * Min.prop. / 60
                               # (rounded down)
#
                   SUBTRACT    # because corr. argt > 6s
Corr. eqn.argt.      2 11      # eqn argt - portion var.diam.
                               # (minus as Far Dist.)

Sum                  8  2      # eqn of centrum + corr. eqn. argt


True place 8th    9 28 17      # mean motus - Sum
                               # (subtract as twice SUBTRACT)



---- JUPITER, 1285 Dec 31, noon; mean motus corrected by -1°:

Mean motus       10  5 48      # i.e. 10s6;47,43° minus 1°

Argument:        11  1 23      # mean motus Sun
                               # - mean motus Jupiter

Apogee:           5 14 30 0    # OK for Jupiter

Centrum:          4 21 18      # mean motus Jupiter - apogee

                   SUBTRACT    # because centrum < 6s
Eqn of centrum:      3 24      # EA51.Ece (centrum = 4s21;18°)

Corr. centrum     4 17 54      # centrum - eqn.c.

Corr. argt       11  4 47      # argt + eqn.c.
```

```
Min. prop.              46      # EA51.Pro
                                # (corr. centrum = 4s17;54°)

Eqn of argt           3 59      # EA51.Ear (corr. argt = 11s4;47°)

Var. diam. ND         0 10      # EA41.Dpr (corr. argt= 11s4;47;
                                # Near Dist. as 3s<centrum<9s)

portion var diam.     0  8      # Var.diam. * Min.prop. / 60

                    SUBTRACT    # because corr. argt > 6s
Corr. eqn.argt.       4  7      # eqn argt + portion var.diam.
                                # (plus as Near Dist.)

Sum                   7 31      # eqn of centrum + corr. eqn. argt


True place 8th     9 28 17      # mean motus - Sum
                                # (subtract as twice SUBTRACT)


# The places of Saturn and Jupiter are equal, no doubt due to
good luck on my part.

Place = 298.28, Tuckerman 308.01 and 307.98, diffs 9.73 and 9.70,
quite consistent.
```

# **§14:** 1226 Mar 4

```
AD 1226 imperf., March 4, about dawn (say, at 6h0m), acc. to
Toulouse Tables: Jupiter in advance of Saturn by more than 1½°.

Checking figures, checkmark is = for not altered, c for altered
[from an earlier calculation, not shown]


SUN, mean motus for 1225y + no months + 3 days + 18 hours [MS,
see on §11, 70r-v]:

1224y:          11  5 58 44* =
1y:             11 29 44 50* c    ## 44'50" is correct.
3d:                2 57 24* =
18h:               0 44 21* =
---------
mean motus      11  9 25 19 c
```

```
---- SATURN [MS, 74r-v], 1226 March 4, 06:00UT, or 18h after noon
on March 3.

1224y:          9 11 37 31* =
1y:             0 12 12 42* =
3d:                0  6  1* =
18h:               0  1 30* =
--------
mean motus      9 23 57 44 =


Argument:       1 15 27 35 c   # mean motus Sun
                               # - mean motus Saturn

Apogee:         8  0  5  0 =

Centrum:        1 23 52 44 =   # mean motus Saturn - apogee

                 SUBTRACT =    # because centrum < 6s
Eqn of centrum:    5  5 =      # EA41.Ece
                               # (centrum = 1s23;52,44°)

Corr. centrum   1 18 48 =      # centrum - eqn.c.
                               # [minus as centrum<6s]

Corr. argt      1 20 33 c      # argt + eqn.c.
                               # [plus as centrum<6s]

Min. prop.           39 =      # EA41.Pro
                               # (corr. centrum = 1s19°)

Eqn of argt        4 28 c      # EA41.Ear
                               # (corr. argt = 1s20;33°)

Var. diam. FD      0 13 =      # EA41.Dlo (corr. argt= 1s20;33°;
                               # Far Dist. as 0s<centrum<3s)

portion var diam.  0  8 =      # Var.diam. * Min.prop. / 60

                    ADD        # because corr. argt < 6s
Corr. eqn.argt.    4 20 c      # eqn argt - portion var.diam.
                               # (minus as Far Dist.)

Sum                0 45 c      # eqn of centrum
                               # - corr.eqn.argt(less)

True place      9 23 13 c      # mean motus - Sum
                               # (subtract as SUBTRACT greater)
```

```
---- JUPITER [MS, 75r-v]

1224y:            8 20 26  1* =  # Poulle has 2", no matter
1y:               1  0 19 41* =
3d:                  0 14 57* =
18h:                 0  3 44* =
--------
Mean motus        9 21  4 23 =


Argument:         1 18 20 56 c   # mean motus Sun
                                 # - mean motus Jupiter

Apogee:           5 14 30  0 =   # OK for Jupiter

Centrum:          4  6 34 23 =   # mean motus Jupiter - apogee

                  SUBTRACT =     # because centrum < 6s
Eqn of centrum:      4 21 =      # EA51.Ece (centrum = 4s6;34,23°)

Corr. centrum     4  2 13 =      # centrum - eqn.c.
                                 # [minus as centrum<6s]

Corr. argt        1 22 42 c      # argt + eqn.c.
                                 # [plus as centrum<6s]

Min. prop.             32 =      # EA51.Pro (corr. centrum = 4s2°)

Eqn of argt          7 48 c      # EA51.Ear
                                 # (corr. argt = 1s22;42°)

Var. diam. ND        0 20 =      # EA41.Dpr (corr. argt= 1s23°;
                                 # Near Dist. as 3s<centrum<9s)

portion var diam.    0 11 =      # Var.diam. * Min.prop. / 60

                      ADD        # because corr. argt < 6s
Corr. eqn.argt.      7 59 c      # eqn argt + portion var.diam.
                                 # (plus as Near Dist.)

Sum                  3 38 c      # - eqn of centrum(less)
                                 # + corr. eqn. argt


True place        9 24 42 c      # mean motus + Sum
                                 # (add as ADD greater)

----

Saturn 9s23;13, Jupiter 9s24;42
```

```
# Thus, Jupiter in advance of Saturn by 1;29°, not quite
consistent with the "more than 1½°" of the text. =
```

# §14: 1226 Mar 4 (mean motions corrected)

```
Using William's corrections for the mean motions of Saturn and
Jupiter.

AD 1226 imperf., March 4, about dawn, cf. above: When applying
the correction -1° to the mean motion of Jupiter and +1;15° to
the mean motion of Saturn, then according to the Toulouse Tables,
Jupiter will be behind Saturn by about a third of a degree.


Sun, mean motus 11  9 25 19 c   # as above


---- SATURN [MS, 74r-v]

Sun, mean motus 11  9 25 19 c   # as above

mean motus Sat   9 25 12 44 =   # former value 9s23;57,44 + 1;15°


Argument:        1 14 12 35 c   # mean motus Sun
                                #  - mean motus Saturn

Apogee:          8  0  5  0 =

Centrum:         1 25  7 44 =   # mean motus Saturn - apogee

                  SUBTRACT =    # because centrum < 6s
Eqn of centrum:     5 10 =      # EA41.Ece (centrum = 1s25;7,44°)

Corr. centrum    1 19 58 =      # centrum - eqn.c.
                                # [minus as centrum<6s]

Corr. argt       1 19 23 c      # argt + eqn.c.
                                # [plus as centrum<6s]

Min. prop.            38 =      # EA41.Pro
                                # (corr. centrum = 1s20°)

Eqn of argt         4 24 =      # EA41.Ear
                                # (corr. argt = 1s19;23°)

Var. diam. FD       0 13 =      # EA41.Dlo (corr. argt= 1s19;23°;
                                # Far Dist. as 0s<centrum<3s)
```

```
portion var diam.   0  8 =      # Var.diam. * Min.prop. / 60

                     ADD =      # because corr. argt < 6s
Corr. eqn.argt.     4 16 =      # eqn argt - portion var.diam.
                                # (minus as Far Dist.)

Sum                 0 54 =      # eqn of centrum
                                # - corr.eqn.argt(less)


True place       9 24 19 =      # mean motus - Sum
                                # (subtract as SUBTRACT greater)



---- JUPITER [MS, 75r-v]

Sun, mean motus 11  9 25 19 c   # as above

Mean motus Jup   9 20  4 23 =   # former value 9s 21;4,23° - 1°


Argument:        1 19 20 56 c   # mean motus Sun
                                # - mean motus Jupiter

Apogee:          5 14 30  0 =   # OK for Jupiter

Centrum:         4  5 34 23 =   # mean motus Jupiter - apogee

                  SUBTRACT =    # because centrum < 6s
Eqn of centrum:     4 24 =      # EA51.Ece (centrum = 4s5;34,23°)

Corr. centrum    4  1 10 =      # centrum - eqn.c.
                                # [minus as centrum<6s]

Corr. argt       1 23 45 c      # argt + eqn.c.
                                # [plus as centrum<6s]

Min. prop.            31 =      # EA51.Pro (corr. centrum = 4s1°)

Eqn of argt         7 55 c      # EA51.Ear
                                # (corr. argt = 1s23;45°)

Var. diam. ND       0 20 =      # EA41.Dpr (corr. argt= 1s24°;
                                # Near Dist. as 3s<centrum<9s)

portion var diam.   0 10 =      # Var.diam. * Min.prop. / 60

                     ADD        # because corr. argt < 6s
Corr. eqn.argt.     8  5 c      # eqn argt + portion var.diam.
                                # (plus as Near Dist.)
```

```
Sum                   3 41 c      # - eqn of centrum(less)
                                  # + corr. eqn. argt


True place        9 23 45 c       # mean motus + Sum
                                  #  (add as ADD greater)

----
```

# Jupiter is now 34' behind Saturn, as against "about 1/3 degree" in the text, a bad fit.

```
Saturn after +1;15° correction: 9s24;19°. Before correction:
9s23;13. =
Jupiter after  -1°  correction: 9s23;45°. Before correction:
9s24;42. c

# Relative to above, increment in true places:
Saturn:  +1;6°  for +1;15° increment in mean motus  -c
Jupiter: -0;57° for -1°    increment in mean motus  =
```

Cf. Will's remark at the end of §15.

# **§17:** 1290 Mar 3, 1290 Apr 21 (mean motion corrected)

Does William's correction of -3° for the mean motion of Mars imply that Mars has the same longitude on 1290 Mar 3 and on 1290 Apr 21 (say, at midnight after the completion of either date)? And is this longitude "about the 21st degree of Scorpio [in the 9th sphere]"?

**1290 March 3, midnight:**

SUN, mean motion for 1289a + no months + 3 days + 12h:

```
1272a:        11  5 40 13* =
17a:          11 29 38 39* =
3d:               2 57 24* =
12h:                29 34* =
--------
Mean motus    11  8 45 50 =
```

```
----MARS (MS f. 76r-v) 1290 at midnight after Mar 3

1272a:         6  4 53 29* =
17a:           0 13 45 12* =
3d:               1 34 19* =
12h:              0 15 43* =
--------
(Mean motus)   6 20 28 43 =

Correction       -3

Mean motus     6 17 28 43 =     # use this for mean motus of Mars


Argument:      4 21 17  7 =     # mean motus Sun
                                #  - mean motus Mars

Apogee:        4  1 51  0       # OK for Mars

Centrum:       2 15 37 43 =     # mean motus Mars - apogee

                SUBTRACT =      # because centrum < 6s =
Eqn of centrum:  10 45 =        # EA61.Ece
                                # (centrum = 2s15;37,43°)

Corr. centrum  2  4 53 =        # centrum - eqn.c.
                                # [minus as centrum<6s]=

Corr. argt     5  2  2 =        # argt + eqn.c.
                                # [plus as centrum<6s]=

Min. prop.          25 =        # EA61.Pro (corr. centrum = 2s5°)

Eqn of argt      36 25 =        # EA61.Ear (corr. argt = 5s2;2°)

Var. diam. FD     5 37 =        # EA61.Dlo (corr. argt= 5s2°;
                                # Far Dist. as 0s<centrum<3s)

portion var diam. 2 20 =        # Var.diam. * Min.prop. / 60

                   ADD =        # because corr. argt < 6s =
Corr. eqn.argt.  34  5 =        # eqn argt - portion var.diam.
                                # (minus as Far Dist.)=

Sum              23 20 =        # - eqn of centrum(less)
                                # + corr. eqn. argt


True place 8th 7 10 49 =        # mean motus + Sum
                                # (add as ADD greater)
```

```
1290 April 21, midnight:

---- SUN, mean motion for 1289a + March + 21 days + 12h:

1272a:         11  5 40 13* =
17a:           11 29 38 39* =
March:          1  0 33 14* =
21d:              20 41 52* =
12h:                 29 34* =
--------
Mean motus      0 27  3 32 =


---- MARS (MS 76r-v) AD 1290 at midnight after April 21

1272a:          6  4 53 29* =
17a:            0 13 45 12* =
March:          0 16 14 43* =
21d:              11  0 17* =
12h:               0 15 43* =
--------
(Mean motus)   (7 16  9 24) =

Correction        -3

Mean motus      7 13  9 24 =     # use this as mean motus for Mars


Argument:       5 13 54  8 =     # mean motus Sun
                                 #  - mean motus Mars

Apogee:         4  1 51  0 =     # OK for Mars

Centrum:        3 11 18 24 =     # mean motus Mars - apogee

                 SUBTRACT =      # because centrum < 6s
Eqn of centrum:  11 20 =         # EA61.Ece (centrum = 3s11°)

Corr. centrum   2 29 58 =        # centrum - eqn.c.
                                 # [minus as centrum<6s]

Corr. argt      5 25 14 =        # argt + eqn.c.
                                 # [plus as centrum<6s]

Min. prop.            3 =        # EA61.Pro (corr. centrum = 3s0°)

Eqn of argt        9  1 =        # EA61.Ear
                                 # (corr. argt = 5s25;14°)

Var. diam. ND      3 40 =        # EA61.Dpr (corr. argt= 5s25;14°;
                                 # Near Dist. as 3s<centrum<9s)
```

```
portion var diam. 0 11 =        # Var.diam. * Min.prop. / 60

                   ADD =        # because corr. argt < 6s
Corr. eqn.argt.   9 12 =        # eqn argt + portion var.diam.
                                # (plus as Near Dist.)

Sum               2  8 =        # eqn of centrum
                                #  - corr. eqn. argt(less)

True place     7 11  1 =        # mean motus - Sum
                                # (subtract as SUBTRACT greater)

-----

# The two places (7s10;49° and 7s11;1°) are 12' apart. I suppose
this is tolerable considering the lack of precision in William's
correction.
```

# §18

```
Centre of epicycle in apogee of deferent: Centrum is 0.
Body of Mars in apogee of epicycle: Argument is 0.

With an error of +3° in the mean motus of Mars we get

## The +3° is the faulty value, from which 3° should be
subtracted to get the correct one, see, e.g., §20.

Argument:     11 27  0  0 =     # WAS mean motus Sun
                                #  - mean motus Mars

Centrum:       0  3  0  0 =     # WAS mean motus Mars - apogee

                 SUBTRACT =     # because centrum < 6s
Eqn of centrum:   0 33 =        # EA61.Ece (centrum = 0s3°)

Corr. centrum  0  2 27 =        # centrum - eqn.c.
                                # [minus as centrum<6s]

Corr. argt    11 27 33 =        # argt + eqn.c.
                                # [plus as centrum<6s]

Min. prop.          60 =        # EA61.Pro (corr. centrum = 0s2°)

Eqn of argt       0 59 =        # EA61.Ear
                                # (corr. argt = 11s27;33°)
```

```
Var. diam. FD      0  3 =        # EA61.Dlo
                                 # (corr. argt= 11s27;33°;
                                 # Far Dist. as 0s<centrum<3s)

portion var diam. 0  3 =         # Var.diam. * Min.prop. / 60

                 SUBTRACT        # because corr. argt > 6s
Corr. eqn.argt.    0 56 =        # eqn argt - portion var.diam.
                                 # (minus as Far Dist.)

Sum                1 29 =        # eqn of centrum
                                 #  - corr. eqn. argt(less)


Error in true motus:
                  +1 31 =        # error +3° - Sum
                                 # (subtract as twice SUBTRACT)


# Against W's +1;32°, good enough.
```

# §19

```
Centre of epicycle in perigee of deferent: Centrum is 6s.
Body of Mars in perigee of epicycle: Argument is 6s.

With an error of +3° in the mean motus of Mars we get

Argument:       5 27  0  0 =     # WAS mean motus Sun
                                 #  - mean motus Mars

Centrum:        6  3  0  0 =     # WAS mean motus Mars - apogee

                    ADD =        # because centrum > 6s
Eqn of centrum:    0 40 =        # EA61.Ece (centrum = 6s3°)

Corr. centrum   6  3 40 =        # centrum + eqn.c.
                                 # [plus as centrum>6s]

Corr. argt      5 26 20 =        # argt - eqn.c.
                                 # [minus as centrum>6s]

Min. prop.           59 =        # EA61.Pro
                                 # (corr. centrum = 6s3;40°)
                                 # Will takes this as 60'

Eqn of argt        6 59 =        # EA61.Ear
                                 # (corr. argt = 5s26;20°)
```

```
                           ## reading "7 36" at EA61.Ear(5s26).
                           ## Reading "7 37", one would get 7;0°.

Var. diam. ND     2 54 =        # EA61.Dpr (corr. argt= 5s26;20°;
                                # Near Dist. as 3s<centrum<9s)

portion var diam. 2 51 =        # Var.diam. * Min.prop. / 60

                   ADD          # because corr. argt < 6s
Corr. eqn.argt.   9 50 =        # eqn argt + portion var.diam.
                                # (plus as Near Dist.)

Sum              10 30 =        # eqn of centrum
                                # + corr. eqn. argt(twice ADD)


Error in true motus:
                 +13 30        # error +3°+ Sum
                               # (add as twice ADD)


# William has "13;34", as he takes Eqn of argt to be 7° and the
variation of diameter to be 2;54 for near distance (thus min.
prop. = 60).

## What if he had the Battani readings in EA51.Dpr, at 5s26° and
5s27°?

5s26° : 3  7 -- 5s27° : 2 23 ($bn, faulty in Ou Co)
>> Var diam ND = 2 52

5s26° : 3  4 -- 5s27° : 2 20 ($ba and older)
>> Var diam ND = 2 49

But he quotes the value 2°54' explicitly, so in these places he
probably had the vulgate Toledan readings.
```

# **§20:** 1292 July 1-2

Moon, AD 1292, midnight after July 1.

Moon's position from Toulouse Tables, for 1291 years elapsed + June elapsed + 1 day + 12h:

MOON, Mean motion (MS=Par.lat.16658, 71r-v), AD 1292, midnight after July 1.

```
1272y:          3  6  1 54* =
19y:            0  3 54 29* c # was 39"
June            5 17 30 55* =
1d:             0 13 10 35* =
12h                6 35 17* =
--------
Sum             9 17 13 10
Correction          +22          # correction, see §10
Moon mean mot.  9 17 35 10 =


MOON, Mean argument (MS, 72r-v):

1272y:          8 16 22  2* =
19y:           10 10 58 52* =
June            5  3 55 40* =
1d:             0 13  3 54* =
12h                6 31 57* =
--------
Moon m.a.       0 20 52 25 =


SUN, Mean motion (MS, 70r-v):

1272y          11  5 40 13* =
19y             0  0  7 27* =
June            4  0 14 39* =
1d                 0 59  8* =
12h                0 29 34* =
--------
Sun m.m.        3  7 31  1 =



Elongation      6 10  4  9 =     # Moon m.m. - Sun m.m.

Centrum moon    0 20  8 18 =     # 2 * elongation, double
elongation

Eqn of centrum     2 58 =        # EA11.Ece (centrum=0s20;8,18)

Min. prop.            2 =        # EA11.Pro (centrum=0s20;8,18)

Corr. argt      0 23 50 =        # argt moon + eqn of centrum
                                 #(plus as centrum<6s)

Eqn of argt        1 52 32 =     # EA11.Ear (corr. argt=0s23;50)

Var.diam.          0 56 =        # EA11.Dbr (corr.argt=0s23;50)

portion var.diam.  0  2 =        # var.diam. * min.prop. / 60
```

```
corr. eqn argt      1 55 =        # eqn argt + portion var.diam.

true place 8th   9 15 40 =        # Moon m.m. - corr. eqn argt
                                  # (subtract as Moon m.argt.<6s)

Motus 8'e          10 15          # for 1292, §2

true place 9th   9 25 55          # agrees with "in the 26th degree
                                  # of Capricorn" (§20)
```

# This is 20' more than the uncorrected value [calculation not shown].

# This also confirms the date and time.

--------

MOON, Almanach, ms. Vat., 2r-3r (2r: preceding opposition is Jun 30 + 16h17m):

1292 Jun 30, noon + 16h17m = Jul 0-1, midnight + 4h17m: Cap 16; 8
d= 11;53
1292 Jul  1, noon + 16h17m = Jul 1-2, midnight + 4h17m: Cap 28; 1

1292 Jul  1-2, midnight: Cap 28;1 - 11;53 * 4;17 / 24 = Cap 28;1 - 2;7
= Cap 25;54.

This is just 1' less than the value computed above, which assumes the correction of +22' to the lunar mean motus, cf. William's remark in §10.

--------

MARS, AD 1292, midnight after July 1, uncorrected.

Mars's position from Toulouse Tables, for 1291 years elapsed + June elapsed + 1 day + 12h, no correction applied to the mean motion:

SUN, Mean motion:

```
Sun m.m.           3  7 31  1 =     # from just above


MARS, mean motion:

1272a              6  4 53 29* =
19a                1  6 49 30* =
June               2  3 55 57* =
1d                    0 31 26* =
12h                   0 15 43* =
--------
Mars m.m.          9 16 26  5 =


Argument:          5 21  4 56 =    # mean motus Sun
                                   # - mean motus Mars

Apogee:            4  1 51  0 =    # OK for Mars

Centrum:           5 14 35  5 =    # mean motus Mars - apogee

                     SUBTRACT      # because centrum < 6s
Eqn of centrum:       3 23 =       # EA61.Ece
                                   # (centrum = 5s14;35,5°)

Corr. centrum      5 11 12 =       # centrum - eqn.c.
                                   # [minus as centrum<6s]

Corr. argt         5 24 28 =       # argt + eqn.c.
                                   # [plus as centrum<6s]

Min. prop.              57 =       # EA61.Pro
                                   # (corr. centrum = 5s11°)

Eqn of argt          10 25 =       # EA61.Ear
                                   # (corr. argt = 5s24;28°)

Var. diam. ND         4 10 =       # EA61.Dpr
                                   # (corr. argt= 5s24;28°;
                                   # Near Dist. as 3s<centrum<9s)

portion var diam.     3 57 =       # Var.diam. * Min.prop. / 60

                       ADD         # because corr. argt < 6s
Corr. eqn.argt.      14 22 =       # eqn argt + portion var.diam.
                                   # (plus as Near Dist.)

Sum                  10 59 =       # - eqn of centrum(less)
                                   # + corr. eqn. argt


True place 8th     9 27 25 =       # mean motus + Sum
                                   # (add as ADD greater)
```

```
Motus 8e            10 15         # for 1292, §2

True place 9th   10  7 40


# This is one degree more than "the 7th degree of Aquarius", not
to bother about.

Mars ought to be in Cap 25, one deg behind the Moon as observed,
but from the tables it is in Aqr 7 [all this from §20]. The "more
than 11 degrees" perhaps refers to a case where Mars is somewhere
within "the 25th degree of Capricorn" in reality, but somewhere
within "the 7th degree of Aquarius" according to the tables.




----

MARS, AD 1292, midnight after July 1, corrected.

Mars's position from Toulouse Tables, for 1291 years elapsed +
June elapsed + 1 day + 12h, correction of -3° applied to the mean
motion:



SUN, Mean motion:

Sun m.m.         3  7 31  1 =    # from just above


MARS, mean motion:

                (9 16 26  5) =  # from just above

                 9 13 26  5 =   # applying correction -3°;
                                # use this as m.m.


Argument:        5 24  4 56 =   # mean motus Sun
                                # - mean motus Mars

Apogee:          4  1 51  0 =   # OK for Mars

Centrum:         5 11 35  5 =   # mean motus Mars - apogee

                  SUBTRACT      # because centrum < 6s
Eqn of centrum:     4  0 =      # EA61.Ece (centrum = 5s11;35°)

Corr. centrum    5  7 35 =      # centrum - eqn.c.
                                # [minus as centrum<6s]
```

```
Corr. argt       5 28  5 =       # argt + eqn.c.
                                 # [plus as centrum<6s]

Min. prop.           56 =        # EA61.Pro (corr. centrum = 5s8°)

Eqn of argt        3 42 =        # EA61.Ear (corr. argt = 5s28;5°)

Var. diam. ND      1 34 =        # EA61.Dpr (corr. argt= 5s28;5°;
                                 # Near Dist. as 3s<centrum<9s)

portion var diam.  1 28 =        # Var.diam. * Min.prop. / 60

                    ADD          # because corr. argt < 6s
Corr. eqn.argt.    5 10 =        # eqn argt + portion var.diam.
                                 # (plus as Near Dist.)

Sum                1 10 =        # - eqn of centrum(less)
                                 # + corr. eqn. argt


True place 8th   9 14 36 =       # mean motus + Sum
                                 # (add as ADD greater)

Motus 8'e          10 15         # for 1292, §2

True place 9th   9 24 51


# This agrees with "in the 25th degree of Capricorn". Also, Mars
is 64' behind the corrected Moon at 9;25,55, in agreement with
"Mars ... one degree behind the Moon" or the observation "Moon
... ahead of Mars by just about 1 degree", both in §20.



---- MARS, Almanach, ms. Vat.:

1292 Jun 24:      Cap 26;42
     Jul 4:       Cap 24; 6

     Jul 4 - 2½d: Cap 24;45

# in indifferent agreement with the result above (6' greater than
9s24;51).
```

# **§21:** 1285 July 1, 03h

Taking no account of the equation of time, or of the discrepancy between the reconstructed times for the real conjunction (3h28m true solar time, [Fabr.]) and for the 12° altitude of Aldebaran (2h51m true solar time).

Check marks: "=" where numbers have been kept from the calculations for 04h [not listed in this file]; "c" where they have been altered; "v", altered and checked.

Argument for mean motion tables: 1272y + 12y + June + no days + 15h.

```
----SUN, mean motion
1272y             11  5 40 13* =
12y               11 29 55 22* =    # "58" Par. 16658
June               4  0 14 39* =
15h                   0 36 58* c
--------
Sun m.m.           3  6 27 12 v

----MOON, mean motion
1272y              3  6  1 54* =
12y                5  1 58  0* =
June               5 17 30 55* =
15h                   8 14  7* c
--------
Sum                2  3 44 56 v
Correction             +22           # cf. §10
Moon m.m.          2  4  6 56 c

----MOON, mean argument
1272y              8 16 22  2* =
12y                0 23 49 11* =
June               5  3 55 40* =
15h                   8  9 57* c
--------
Moon m.argt        2 22 16 50 v

----MARS, mean motion
1272y              6  4 53 29* =
12y                4 16 51 34* =
June               2  3 55 57* =
15h                   0 19 39* c
--------
Mars m.m.          0 26  0 39 v
```

```
----SUN, true place, 1285 JULY 1st, 03h -c

Mean mot.          3  6 27 12 c

Apogee             2 17 50 10 =

Argument           0 18 37  2 v    # Mean motion - apogee

Eqn                   0 36 49 c    # EA01 (argt = 0s18;37,2°)

True pl            3  5 50 23 c    # subtract eqn as argt < 6s


----MOON, true place, 1285 JULY 1st, 03h, applying W's correction
of +22' to the mean motion.

Moon m.m.          2  4  6 56 =   # as above

Moon m.arg         2 22 16 50 =   # as above

Sun m.m.           3  6 27 12 =   # as above


Elongation        10 27 39 44 =   # Moon m.m. - Sun m.m.

Centrum moon       9 25 19 28 =   # 2 * elongation,
                                  # double elongation

Eqn of centrum        9 12 =      # EA11.Ece (centrum=9s25;19,28)

Min. prop.              15 =      # EA11.Pro (centrum=9s25)

Corr. argt         2 13  5 =      # argt moon - eqn of centrum
                                  # (minus as centrum>6s)

Eqn of argt           4 40 =      # EA11.Ear
                                  # (corr. argt=2s13;5)

Var.diam.             2 19 =      # EA11.Dbr
                                  # (corr.argt=2s13;5)

portion var.diam.     0 35 =      # var.diam. * min.prop. / 60

corr. eqn argt        5 15 =      # eqn argt
                                  # + portion var.diam.

true place 8th     1 28 52 =      # Moon m.m. - corr. eqn argt
                                  # (subtract as Moon m.argt.<6s)

# Corrected true place is 22' greater than uncorrected [not
shown], like the mean motion.
```

```
----MARS, true place, 1285 JULY 1st, 03h, not applying W's
correction

Sun m.m.            3  6 27 12 c

Mars m.m.           0 26  0 39 c


Argument:           2 10 26 33 c    # mean motus Sun
                                    # - mean motus Mars

Apogee:             4  1 51  0 =    # OK for Mars

Centrum:            8 24  9 39 c    # mean motus Mars - apogee

                       ADD          # because centrum > 6s
Eqn of centrum        11 24 =       # EA61.Ece
                                    # (centrum = 8s24;9,39°)

Corr. centrum       9  5 34 c       # centrum + eqn.c.
                                    # [plus as centrum>6s]

Corr. argt          1 29  3 c       # argt - eqn.c.
                                    # [minus as centrum>6s]

Min. prop.                4 =       # EA61.Pro
                                    # (corr. centrum = 9s5;34°)

Eqn of argt           22 52 =       # EA61.Ear
                                    # (corr. argt = 1s29;3°)

Var. diam. ND          1 38 =       # EA61.Dpr
                                    # (corr. argt= 1s29;3°;
                                    # Near Dist. as 3s<centrum<9s)

portion var diam.      0  7 =       # Var.diam. * Min.prop. / 60

                       ADD          # because corr. argt < 6s
Corr. eqn.argt.       22 59 =       # eqn argt + portion var.diam.
                                    # (plus as Near Dist.)

Sum                 1  4 23 =       # eqn of centrum
                                    # + corr. eqn. argt


True place          2  0 24 c       # mean motus + Sum
                                    # (add as twice ADD)

# This is 1;32° greater than the Moon's place. -c
```

```
----MARS, true place, 1285 JULY 1st, 03h, applying W's correction
of -3° to the mean motus of Mars.

Sun m.m.            3  6 27 12 c

Mars m.m.           0 23  0 39 c   # 0s26;0,39° - 3°


Argument:           2 13 26 33 c   # mean motus Sun
                                   # - mean motus Mars

Apogee:             4  1 51  0 =   # OK for Mars

Centrum:            8 21  9 39 c   # mean motus Mars - apogee

                      ADD          # because centrum > 6s
Eqn of centrum:      11 22 =       # EA61.Ece (centrum = 8s21;9°)

Corr. centrum       9  2 32 c      # centrum + eqn.c.
                                   # [plus as centrum>6s]

Corr. argt          2  2  5 c      # argt - eqn.c.
                                   # [minus as centrum>6s]

Min. prop.                1 =      # EA61.Pro (corr. centrum =
9s3°)

Eqn of argt          23 59 =       # EA61.Ear (corr. argt = 2s2;5°)

Var. diam. ND         1 44 =       # EA61.Dpr (corr. argt= 2s2;5°;
                                   # Near Dist. as 3s<centrum<9s)

portion var diam.     0  2 =       # Var.diam. * Min.prop. / 60

                       ADD         # because corr. argt < 6s
Corr. eqn.argt.      24  1 =       # eqn argt + portion var.diam.
                                   # (plus as Near Dist.)

Sum                 1  5 23 =      # eqn of centrum
                                   # + corr. eqn. argt


True place          1 28 24 c      # mean motus + Sum
                                   # (add as twice ADD)

# This is 6' less than the uncorrected Moon's place. -c
```

# §21: 1293 May and June

```
1293 "in Maio vel Iunio":

Tuckerman                  4 May: Mars    83.33      D(1d) = 0.642
                          14 May: Mars    89.75

Linear for 4 May + 5.38d   9 May: Mars    86.78


Tuckerman                  9 May: Moon    81.4       D(1d )= 14.26
                          14 May: Moon   152.7

Linear for 9 May + 0.38d   9 May: Moon    86.8



Tuckerman                  3 Jun: Mars   102.52      D(1d) = 0.636
                          13 Jun: Mars   108.88

Linear for 3 Jun + 4d:     7 Jun: Mars   105.06

Tuckerman                  3 Jun: Moon    47.7       D(1d) = 14.42
                           8 Jun: Moon   119.8

Linear for 3 Jun + 4d:     7 Jun: Moon   105.4

# So there are conjunctions on

1293 May 9, 16:00UT + 0.38d = ...+ 9;7h
= 1293 May 10, 01:07UT

1293 Jun 7, 16:00UT - elongation / motus of elongation
= ... - (105.4 - 105.06) / (14.42 - 0.64) * 24 = 0;31h
= 1293 Jun 7, 15;29UT



----

Finding place of Mars for 1293 May 10, 01h07m = 1292y elapsed +
April elapsed + 9 days + 13h, ignoring the 7 minutes. If William
is right, then both the centrum and the argument should be close
to zero.

**No correction applied to the mean motion of Mars **

----SUN mean motion

1272y           11  5 40 13*
```

```
20y             11 29 52 17*
April            2  0  7 20*
9d                  8 52 13*
13h                 0 32  2*
--------
Sun m.m          1 15  4  5

----MARS mean motion

1272y            6  4 53 29*
20y              7 18  5 57*
April            1  1 57 59*
9d                  4 42 59*   # 58" TT, doesn't matter
13h                 0 17  2*
--------
Mars m.m         2 29 57 26

Argument:       10 15  6 39    # mean motus Sun - mean motus Mars

Apogee Mars:     4  1 51  0    # OK Mars

Centrum:        10 28  6 26    # mean motus Mars - apogee

                     ADD       # because centrum > 6s
Eqn of centrum:     5 35       # EA61.Ece (centrum = 10s28;6°)

Corr. centrum   11  3 41       # centrum + eqn.c.
                               # [plus as centrum>6s]

Corr. argt      10  9 32       # argt - eqn.c.
                               # [minus as centrum>6s]

Min. prop.            54       # EA61.Pro (corr. centrum = 11s4°)

Eqn of argt        19 41       # EA61.Ear (corr. argt = 10s9;32°)

Var. diam. FD       1 12       # EA61.Dlo (corr. argt= 10s9;32°;
                               # Far Dist. as 9s<centrum<12s)

portion var diam.   1  5       # Var.diam. * Min.prop. / 60

                 SUBTRACT      # because corr. argt > 6s
Corr. eqn.argt.    18 36       # eqn argt - portion var.diam.
                               # (minus as Far Dist.)

Sum                13  1       # - eqn of centrum(less)
                               # + corr. eqn. argt

True place 8th   2 16 56       # mean mot. - Sum
                               # (subtract as SUBTRACT greater)

Motus 8e:          10 16
```

```
True place 9th:  2 27 12


# In the Almanach, the longitude of Mars (for noon on 1293 May
10) is given as Gem 25;50°, or 1;22° lower than the computation.
This is a fair fit to the postulated minimum difference of 1;32°.
But I have not re-checked the computation.



---- For good measure: Argument and centrum for Mars, 1293 Jun 7,
15h29m = 1292y elapsed + May elapsed + 7 days + 3h + 30m, say.

**No correction applied to the mean motion of Mars **

----SUN mean motion

1272y              11  5 40 13*
20y                11 29 52 17*
May                 3  0 40 33*
7d                     6 53 57*
3h                     0  7 24*
30m                    0  1 14*
--------
Sun m.m.            2 13 15 38

----MARS mean motion

1272y               6  4 53 29*
20y                 7 18  5 57*
May                 1 18 12 41*
7d                     3 40  6*    # 5" TT, no matter
3h                     0  3 56*
30m                       0 39*
--------
Mars m.m.           3 14 56 48

Argument:          10 28 18 50     # mean motus Sun
                                   # - mean motus Mars

Apogee Mars:        4  1 51  0     # OK Mars

Centrum:           11 13  5 48     # mean motus Mars - apogee

                        ADD        # because centrum > 6s
Eqn of centrum:        3  2        # EA61.Ece
                                   # (centrum = 11s13;6°)

Corr. centrum      11 16  8        # centrum + eqn.c.
                                   # [plus as centrum>6s]
```

```
Corr. argt          10 25 17          # argt - eqn.c.
                                      # [minus as centrum>6s]


# Look no further; here we are even closer to the apogees, and
this tendency will go on for some months, the mean centrum being
incremented by about 15°, and the mean argument by about 13°, for
successive conjunctions.
```

## §42: 1294 March 1

```
Degree of Sun on March 1, 1294, noon (= "Psc 18;31" both in §42
and in Almanach for 1294).

One day is to be added to the end of 1293, as the value is for
the noon at the end of the astronomical day March 1, see §26.

1272a:          11  5 40 13*
21a:            11 29 37  7*
1d:                 0 59  8*
--------
m.m.            11  6 16 28

Apogee           2 17 50 10

Argument         8 18 26 18     # Mean motion - apogee

Eqn                 1 57 28     # EA01 (argt = 8s18;26°)

True pl         11  8 13 56     # add eqn to m.m. as argt > 6s

Motus 8e           10 17        # from 1294 page of Almanach

9th sphere      11 18 31        # Psc 18;31°, OK



---- Daily arc on March 1 (169;41° in table §47):

From table BG17, ascensions for 7th clime:

Trying for entire degrees:

Vir 18      163;37
Psc 18     -354;23
--------
Diff:       169;14    # No.
```

```
Trying half-degrees:

Vir 18½    164;18
Psc 18½   -354;37    # 354;23 plus 0;29/2 =
                     # 0;14 (as here) or 0;15
--------
Diff:      169;41    # OK but bad example

Trying precise interpolation:

Vir 18     163;37
Vir 19     164;59    D(1)=+1;22  D(0;31)=+0;42,22
Vir 18;31  164;19

Psc 18     354;23
Psc 19     354;52    D(1)=+0;29  D(0;31)=+0;14,59
Psc 18;31 -354;38

Diff       169;41  # OK
```

# **§§43 and 47:** 1294 March 1

```
March 1, (1294):

Equal hours of day = Daily arc / 15 = 169;41 /15 = 11;18,44h
("11;19", OK)

Parts of hours = Daily arc / 12 = 169;41 / 12 = 14;8,25° ("14;8",
OK)

Equation of time ("5 minutes"): table BB11 (Psc 18°) 1;12°, (Psc
19°) 1;15°, thus our value is in minutes of an hour, round 4
times the tabular value.

Solar declination ("4;34° S", for max decl 23;33°, §41): trying
table BA21 (for max decl 23;33,30). -- Longitude 348;31° -> argt
11;29°. f(11°) = 4;22,28; f(12°) = 4;46,0 -> f(11;29°) = 4;33,50.
-- OK, not very telling.
```

# Appendix: Tables of Almanach

Three samples for the arbitrary dates 1293 October 17; 1301 July 29; 1309 April 20.

I had applied William's suggested corrections to Saturn, Jupiter and Mars, but not to the Moon.

Statistics: Almanach values *minus* Calculated values, in minutes of arc:

| | 1293 | 1301 | 1309 | |
|---|---|---|---|---|
| Sun | +2 | 0 | +1 | |
| Moon | +19 | +24 | +17 | # this is systematic |
| Saturn | -16* | -3 | +8 | |
| Jupiter | 0 | +2 | 0 | |
| Mars | 0 | +7 | +2 | |
| Venus | +15* | +3 | 0 | |
| Mercury | +4 | +11* | +4 | |

* Saturn 1293, Venus 1293 and Mercury 1301 checked again, no errors discovered in the present calculations.

# No doubt William has applied some increment for the Moon, like that suggested as 22' in §10.

# Discounting the Moon, the median excess of the Almanach values over the calculated is 2', for what it is worth.

# Tables: 1293 October 17, etc.

```
Sample of values, to be checked from the Toulouse Tables. "q"=
Par.16201,9v; "v"=Vat.4572,14v.
```

Date chosen arbitrarily: **1293 Oct 17, noon;**

```
(for Saturn) 1293 Oct 16, noon (closest date with an un-rounded
value);

(for Moon) 1293 Oct 17, noon + 4h2m (as the preceding mean
opposition was on Oct 16 + 4h + 2m).

Motus 8'e sphere: 10°16' for 1293.

Sun:                        Sco  1;52 = 7s  1;52  qv
Moon (+4h2m):               Tau 10;55 = 1s 10;55  qv
Saturn (Oct 16. Retrogr.):  Tau 21;32 = 1s 21;32  qv
Jupiter:                    Lib 14;32 = 6s 14;32  qv
Mars:                       Lib  8;18 = 6s  8;18  qv
Venus:                      Sco  4;25 = 7s  4;25  qv
Mercury:                    Sco  5;28 = 7s  5;28  qv
Caput:                      Cnc 13;37 = 3s 13;37  qv
Latitudo lunæ:                  -4;26 qv

Media coniunctio: [...]

Media oppositio: 16d 4h 2m; medius lunae 0s 22;25; argm. lunae 2s
3;33; buth solis 2'31"; buth lunae 31'31". qv

CHECKMARKS FOR MEAN MOTION VALUES: p = Poulle 1994; t = Toledan,
Pedersen 2002; "=" = checked from Vat. 4572.

For other values, "=" means that the figures have been re-
checked.


---- SUN: 1293 Oct 17, noon ----

1272a:          11  5 40 13 =p
20a:            11 29 52 17 =p
September:       7  0 55 13 =p
17d:               16 45 19 =t
--------
Mean motion:     6 23 13  2 =

Apogee           2 17 50 10    # to be subtracted, Cb141a

Argt:            4  5 22 52 == # mean mot. - apogee
```

```
Eqn:                 1 39  8 =  # EA01 (argt=4s5;22,52)
                                # to be subtracted
                                # since argt < 6s, Cb141b
--------
True:             6 21 33 54 =  # mean mot. - eqn

Motus 8'ae:         10 16
--------
Place 9th:        7  1 50       # 7s1;52 in Almanach, OK I suppose


# The Almanach value requires the equation 1;37°, corresponding
to the argument 4s7° and the mean motion 6s25°. This mean motion
cannot be had from the tables, nor is it that presupposed in the
equations of Venus and Mercury, below.



---- MOON: 1293 Oct 17, noon + 4h + 2m ----

Sun, m.m., noon:   6 23 13  2       # from just above
4h:                   0  9 51
2m:                   0  0  5
--------
SUN, mean motion:  6 23 22 58



1272a:             3  6  1 54 =p
20a:               4 13 16 40 =p
September:         9 29 44 24 =p
17d:               7 13 59 54 =t
4h:                   2 11 46 =t
2m:                   0  1  6 =t
--------
MOON, mean motion: 1  5 15 44 =


1272a:             8 16 22  2 =p
20a:               1  9 41 59 =p
September:         9  5 54 22 =p
17d:               7 12  6 17 =t
4h:                   2 10 39 =t
2m:                   0  1  5 =t
--------
MOON, mean argt:   2 16 16 24 =


Elongation         6 11 52 46 =     # Moon m.m. - Sun m.m.

Centrum moon       0 23 45 32 =     # 2 * elongation,
                                    # double elongation
```

```
Eqn of centrum        3 29 =        # EA11.Ece
                                    # (centrum=0s23;45,32)

Min. prop.               2 =        # EA11.Pro
                                    # (centrum=0s23;45,32)

Corr. argt         2 19 45 =        # argt moon + eqn of centrum
                                    # (plus as centrum<6s)

Eqn of argt           4 51 =        # EA11.Ear
                                    # (corr. argt=2s19;45)

Var.diam.             2 26 =        # EA11.Dbr (corr.argt=2s19;45)

portion var.diam.     0  5 =        # var.diam. * min.prop. / 60

corr. eqn argt        4 56 =        # eqn argt + portion var.diam.

true place         1  0 20          # Moon m.m. - corr. eqn argt
                                    # (subtract as Moon m.a.<6s)
----
motus 8'e            10 16

Place              1 10 36          # 1s 10;55 in Almanach,
                                    # 19' greater than this

# The place from ToulT is 19' less than in the Almanach. On 1292
July 1, midnight, the lunar longitude from ToulT was also 19'
less, see note to canons §20.


-------- MOON, trying again but adding 22' to the mean motus, cf.
Canons §10. ----

# In this case, the 22' might as well have been added directly to
the true place.

SUN, mean motion:  6 23 22 58       # from above
MOON, mean motion: 1  5 37 44       # "1s 5;15,44°" plus 0;22°
MOON, mean argt:   2 16 16 24       # from above

Elongation         6 12 14 46 =     # Moon m.m. - Sun m.m.

Centrum moon       0 24 29 32 =     # 2 * elongation,
                                    # double elongation

Eqn of centrum        3 35 =        # EA11.Ece
                                    # (centrum=0s24;29,32)

Min. prop.               2 =        # EA11.Pro
                                    # (centrum=0s24;29,32)
```

```
Corr. argt          2 19 51 =       # argt moon + eqn of centrum
                                    # (plus as centrum<6s)

Eqn of argt            4 51 =       # EA11.Ear
                                    # (corr. argt=2s19;51)

Var.diam.              2 26 =       # EA11.Dbr (corr.argt=2s19;51)

portion var.diam.      0  5 =       # var.diam. * min.prop. / 60

corr. eqn argt         4 56 =       # eqn argt + portion var.diam.

true place          1  0 42 =       # Moon m.m. - corr. eqn argt
                                    # (subtract as Moon m.a.<6s)
----
motus 8'e             10 16 =

Place               1 10 58 =       # 1s10;55 in Alman.,
                                    # a lot better than before.



-------- SATURN, 1293 Oct 16, noon, mean motion corrected ------

---- SUN mean motion
1272a:          11  5 40 13 =p
20a:            11 29 52 17 =p
September:       7  0 55 13 =p
16d:               15 46 11 =t
--------
SUN mean motion: 6 22 13 54 =


---- SATURN mean motion, Toulouse tables, Par.lat. 16658, 74r-v.
Applying the correction of +1;15° to the mean motion, cf. canons
§12.

1272a:           4 28 11  1 =p
20a:             8  4 23 58 =p
September:       0  7  9 35 =p
16d:                0 32  7 =t
--------
Sum:             1 10 16 41 =
Correction:        +1 15
SATURN mean mot: 1 11 31 41 =


Argument:        5 10 42 13 =   # mean motus Sun
                                # - mean motus Saturn

Apogee:          8  0  5  0     # OK Saturn
```

```
Centrum:          5 11 26 41 =   # mean motus Saturn - apogee

                   SUBTRACT =    # because centrum < 6s
Eqn of centrum:      2 11 =      # EA41.Ece
                                 # (centrum = 5s11;26,41°)

Corr. centrum     5  9 16 =      # centrum - eqn.c.
                                 # (minus as centrum <6s)

Corr. argt        5 12 53 =      # argt + eqn.c.
                                 # (plus as centrum <6s)

Min. prop.             56 =      # EA41.Pro
                                 # (corr. centrum = 5s9;16°)

Eqn of argt          2  3 =      # EA41.Ear
                                 # (corr. argt = 5s12;53°)

Var. diam. ND        0  9 =      # EA41.Dpr (corr. argt= 5s12;53;
                                 #  Near Dist. as 3s<centrum<9s)

portion var diam.    0  8 =      # Var.diam. * Min.prop. / 60

                      ADD        # because corr. argt < 6s
Corr. eqn.argt.      2 11 =      # eqn argt + portion var.diam.
                                 # (plus as Near Dist.)
                                 # **Sign error?**

Sum                  0  0        # eqn of centrum
                                 # - corr. eqn. argt (as SUB, ADD)


True place 8'a    1 11 32        # mean motus - Sum (SUB = ADD)

motus 8'e           10 16

True place 9'a    1 21 48        # 1s 21;32 in Almanach, not good
                                 # enough. Sign error above?


# Calculation checked again, no errors found in arithmetic,
signs, or interpolated values. Mean motion values not checked
again but should be correct.



-------- JUPITER, 1293 Oct 17, noon, mean motion corrected -----

SUN, mean motion:   6 23 13  2 =  # from above
```

```
---- JUPITER mean motion, Toulouse tables, Par.lat. 16658, 75r-v.
Applying the correction of -1° to the mean motion, cf. canons
§12.

1272a:              9  7 10 57 =p
20a:                8  6 58 42 =p
September:          0 17 46 53 =p
17d:                   1 24 45 =t   # 46" TT
--------
Sum:                6  3 21 17 =
Correction:           -1
JUPITER, mean m.:   6  2 21 17 =

#

Argument:         0 20 51 45 =     # mean motus Sun
                                   # - mean motus Jupiter

Apogee:           5 14 30  0       # OK for Jupiter

Centrum:          0 17 51 17 =     # mean motus Jupiter - apogee

                   SUBTRACT =      # because centrum < 6s
Eqn of centrum:     1 32 =         # EA51.Ece
                                   # (centrum = 0s17;51,17°)

Corr. centrum     0 16 19 =        # centrum - eqn.c.
                                   # [minus as centrum<6s]

Corr. argt        0 22 24 =        # argt + eqn.c.
                                   # [plus as centrum<6s]

Min. prop.             59 =        # EA51.Pro
                                   # (corr. centrum = 0s16;19°)

Eqn of argt         3 34 =         # EA51.Ear
                                   # (corr. argt = 0s22;24°)


Var. diam. FD       0  7 =         # EA51.Dlo
                                   # (corr. argt= 0s22;24°;
                                   # Far Dist. as 0s<centrum<3s)

portion var diam.   0  7 =         # Var.diam. * Min.prop. / 60

                      ADD =        # because corr. argt < 6s
Corr. eqn.argt.     3 27 =         # eqn argt - portion var.diam.
                                   # (minus as Far Dist.)

Sum                 1 55 =         # - eqn of centrum(less)
                                   # + corr. eqn. argt
```

```
True place       6  4 16 =        # mean motus + Sum
                                  # (add as ADD greater)

Motus 8'e          10 16
-----
true place 9th   6 14 32          # = same as in Almanach




-------- MARS, 1293 Oct 17, noon, mean motion corrected --------

SUN, mean motion:  6 23 13  2 =  # from above

---- MARS mean motion, Toulouse tables, Par.lat. 16658, 76r-v.
Applying the correction of -3° to the mean motion, cf. canons
§17.

1272a:             6  4 53 29 =p
20a:               7 18  5 57 =p
September:         3 22  8 39 =p
17d:                  8 54 31 =t
--------
Sum:               5 24  2 36 =
Correction:          -3
MARS, mean m.:     5 21  2 36 =


Argument:          1  2 10 26 =   # mean motus Sun
                                  # - mean motus Mars

Apogee:            4  1 51  0     # OK for Mars

Centrum:           1 19 11 36 =   # mean motus Mars - apogee

                   SUBTRACT       # because centrum < 6s
Eqn of centrum:       8  7 =      # EA61.Ece
                                  #(centrum = 1a19;11,36°)

Corr. centrum      1 11  5 =      # centrum - eqn.c.
                                  # [minus as centrum<6s]

Corr. argt         1 10 17 =      # argt + eqn.c.
                                  # [plus as centrum<6s]

Min. prop.              45 =      # EA61.Pro
                                  #(corr. centrum = 1s11;5°)

Eqn of argt          15 50 =      # EA61.Ear
                                  # (corr. argt = 1s10;17°)
```

```
Var. diam. FD          0 58 =       # EA61.Dlo
                                    # (corr. argt= 1s 10;17°;
                                    # Far Dist. as 0<centrum<3s)

portion var diam       0 44 =!      # Var.diam. * Min.prop. / 60
                                    # [rounded from 0;43,30]

                        ADD         # because corr. argt < 6s
Corr. eqn.argt.       15  6 =       # eqn argt - portion var.diam.
                                    # (minus as Far Dist.)

Sum                    6 59 =       # - eqn of centrum
                                    # + corr. eqn. argt (SUB,ADD)

True place           5 28  2 =      # mean motus + Sum
                                    #(add as ADD > SUB)

+ motus 8'e           10 16

True place 9th       6  8 18        # = same as in Almanach



---- VENUS, 1293 Oct 17, noon, no correction for mean motion ----

VENUS, mean mot.     6 23 13  2 =   # same as SUN's mean motion
from above

---- VENUS, argument, Toulouse tables, Par.lat. 16658, 77r-v:

1272a:               1  7 45 17 =p
20a:                 6  3 43  1 =p
September:           4 11 56 11 =p
17d:                   10 28 51 =t   # 52" TT
--------
VENUS, argt:         0  3 53 20 =


Argument:            0  3 53 20 =   # see above

Apogee:              2 17 50 10 =   # OK for Venus

Centrum:             4  5 22 52 =   # mean motus Venus - apogee

                     SUBTRACT =     # because centrum < 6s
Eqn of centrum:         1 40 =!     # EA71.Ece
                                    # (centrum = 4s5;22,52°)
                                    # [Variant, could be 1;39]

Corr. centrum        4  3 43 =      # centrum - eqn.c.
                                    # [minus as centrum<6s]
```

```
Corr. argt          0  5 33 =      # argt + eqn.c.
                                   # [plus as centrum<6s]

Min. prop.                33 =     # EA71.Pro
                                   # (corr. centrum = 4s3;43°)

Eqn of argt            2 20 =      # EA71.Ear
                                   # (corr. argt = 0s5;33°)

Var. diam. ND          0  2 =      # EA71.Dpr
                                   #(corr. argt= 0s5;33°;
                                   # Near Dist. as 3s<centrum<9s)

portion var diam.      0  1 =      # Var.diam. * Min.prop. / 60

                        ADD =      # because corr. argt < 6s
Corr. eqn.argt.        2 21 =      # eqn argt + portion var.diam.
                                   # (plus as Near Dist.)

Sum                    0 41 =      # - eqn of centrum
                                   # + corr. eqn. argt (SUB,ADD)

True place          6 23 54 =      # mean motus + Sum
                                   #(add as ADD > SUB)

+ motus 8'e           10 16

True place 9th      7  4 10 =      # 7s4;25 in Almanach;
                                   # error somewhere


# Calculation checked again, no errors found in arithmetic,
signs, or interpolated values. Mean motion values not checked
again but should be correct.



--- MERCURY, 1293 Oct 17, noon, no correction for mean motion ---

Note that the minuta proportionalia are to be treated in a
special way, see Cb151.


MERC., mean mot.: 6 23 13  2 =  # same as SUN's mean motion from
above

---- MERCURY, argument, Toulouse tables, Par.lat. 16658, 78r-v:

1272a:           11 26 34 29 =p
20a:              0 14 27 32 =p
September:       10  4 50  3 =p
17d:              1 22 48 50 =t
-------
```

```
MERC., argt:        0  8 40 54 =


Argument:           0  8 40 54 =    # see above

Apogee:             6 17 30  0 =    # OK for Mercury

Centrum:            0  5 43  2 =    # mean motus Mercury/Sun -
apogee

                     SUBTRACT =     # because centrum < 6s
Eqn of centrum:        0 16 =       # EA81.Ece (centrum = 0s5;43,2°)

Corr. centrum       0  5 27 =       # centrum - eqn.c.
                                    # [minus as centrum<6s]

Corr. argt          0  8 57 =       # argt + eqn.c.
                                    # [plus as centrum<6s]

Min. prop.               -59 =      # EA81.Pro
                                  #(corr. centrum = 0s5;27°) MINUS!

Eqn of argt            2 26 =       # EA81.Ear
                                    # (corr. argt = 0s8;57°)

Var. diam. FD          0 15 =       # EA81.Dlo
                                    #(corr. argt= 0s8;57°;
                                    # Far Dist. as 0s<centrum<3s)

portion var diam.   -0 15 =         # Var.diam. * Min.prop. / 60

                        ADD =       # because corr. argt < 6s
Corr. eqn.argt.        2 11 =       # eqn argt - |portion var.diam|.
                                    # MINUS from Min.prop.

Sum                    1 55 =       # - eqn of centrum
                                    # + corr. eqn. argt (SUB,ADD)

True place          6 25  8 =       # mean motus + Sum
                                    # (add as ADD > SUB)

+ motus 8'e           10 16 =

True place 9th      7  5 24 =       # 7s 5;28 in Almanach
```

# Tables: 1301 July 29, etc.

```
Sample of values, to be checked from the Toulouse Tables. "q"=
Par.16201, 102v; "v"=Vat.4572, 75r.
```

Date chosen arbitrarily: **1301 July 29, noon;**

```
(for Saturn) 1301 July 26, noon (closest date with an un-rounded
value);

(for Moon) 1301 July 29, noon + 2h31m (as the preceding mean
opposition was on July 21 + 2h + 31m).

Motus 8'e sphere: 10°23' for 1301. qv

Sun:                       Leo 13;18 =  4s 13;18  qv
Moon (+2h31m):             Tau 15;28 =  1s 15;28  qv
Saturn (Jul 26):           Vir  1;10 =  5s  1;10  qv
Jupiter:                   Gem 22;47 =  2s 22;47  qv
Mars:                      Lib  7;44 =  6s  7;44  qv
Venus:                     Cnc 25;51 =  3s 25;51  qv
Mercury (Retrog.):         Leo  8;37 =  4s  8;37  qv
Caput:                     Aqr 13; 8 = 10s 13; 8  qv
Latitudo lunæ:                 +5; 0 qv

Media coniunctio [...]

Media oppositio: 21d 2h 31m; medius lunae 9s 26;34; argm. lunae
0s 21;58; buth solis 2'24"; buth lunae 30'27". qv

CHECKMARKS FOR MEAN MOTION VALUES: p = Poulle 1994; t = Toledan,
Pedersen 2002; "=" = checked from Vat. 4572.

For other values, "=" means that the figures have been re-
checked.



---- SUN: 1301 July 29, noon ----

1296a:          11  5 30 57 =p
4a:             11 29 58 27 =p
June:            4  0 14 39 =p
29d:             0 28 34 57 =t
--------
```

**SUN Mean motion: 4  4 19  0** =

```
Apogee           2 17 50 10 =  # to be subtracted, Cb141a

Argt:            1 16 28 50 =  # mean mot. - apogee
```

```
Eqn:                 1 24 21 =  # EA01 (argt=1s16;28,50)
                                # to be subtracted
                                # since argt < 6s, Cb141b
--------
True:             4  2 54 39 =  # mean mot. - eqn

Motus 8'ae:        10 23        # for 1301
--------
Place:            4 13 17 39    # = same as in Almanach
```

```
---- MOON: 1301 July 29, noon + 2h + 31m ----

-- Sun, mean motion
Sun, m.m. noon    4  4 19  0 =   # from just above
2h:               0  0  4 56 =t
24m:              0  0  0 59 =t  # hour value, shifted and rounded
7m:               0  0  0 17 =t  # same
--------
SUN, mean mot.:   4  4 25 12 =


-- Moon, mean motion
1296a:            1  9 57 53 =p
4a:               5 20 39 20 =p
June:             5 17 30 55 =p
29d:              0 22  6 52 =t
2h:               0  1  5 53 =t
24m:              0  0 13 11 =t  # same
7m:               0  0  3 51 =t  # same
--------
MOON, mean mot.   1 11 37 55 =

-- Moon, mean argument
1296a:           10  4  0 25 =p
4a:               0  7 56 23 =p
June:             5  3 55 40 =p
29d:              0 18 53  4 =t
2h:               0  1  5 20 =t
24m:              0  0 13  4 =t  # same
7m:               0  0  3 49 =t  # same
--------
MOON, mean argt   4  6  7 45 =


Elongation        9  7 12 43 =    # Moon m.m. - Sun m.m.

Centrum moon      6 14 25 26 =    # 2 * elongation,
                                  # double elongation
```

```
Eqn of centrum      4 57 =       # EA11.Ece (centrum=6s14;25,26)

Min. prop.            59 =       # EA11.Pro (centrum=6s14;25,26)

Corr. argt      4  1 11 =        # argt moon - eqn of centrum
                                 #(minus as centrum>6s)

Eqn of argt         4 29 =       # EA11.Ear (corr. argt=4s1;11)

Var.diam.           2 30 =       # EA11.Dbr (corr.argt=4s1;11)

portion var.diam.   2 28 =       # var.diam. * min.prop. / 60

corr. eqn argt      6 57 =       # eqn argt + portion var.diam.

true place      1   4 41 =       # Moon m.m. - corr. eqn argt
                                   #  (subtract as Moon m.a.<6s)
----
motus 8'e          10 23 =       # for 1301

Place           1 15  4 =        # 1;15,28 in Alman.,
                                 # 24' greater than this



------ SATURN, 1301 July 26, noon, mean motion corrected ------

---- SUN mean motion
1296a:          11  5 30 57 =p
4a:             11 29 58 27 =p
June:            4  0 14 39 =p
26d:             0 25 37 32 =t
--------
SUN mean mot.:   4  1 21 35 =



---- SATURN mean motion, Toulouse tables, Par.lat. 16658, 74r-v.
Applying the correction of +1;15° to the mean motion, cf. canons
§12.

1296a:           2 21 27 46 =p
4a:              1 18 52 48 =p
June:            0  4  4 54 =p
26d:             0  0 52 12 =t
--------
Sum:             4 15 17 40 =
Correction:        +1 15
SATURN mean mot: 4 16 32 40 =
```

```
Argument:        11 14 48 55 =   # mean motus Sun
                                 # - mean motus Saturn

Apogee:           8  0  5  0 =   # OK Saturn

Centrum:          8 16 27 40 =   # mean motus Saturn - apogee

                      ADD        # because centrum > 6s
Eqn of centrum:      6 24 =      # EA41.Ece
                                 # (centrum = 8s16;27,40°)

Corr. centrum     8 22 52 =      # centrum + eqn.c.
                                 # (plus as centrum >6s)

Corr. argt       11  8 25 =      # argt - eqn.c.
                                 # (minus as centrum >6s)

Min. prop.             10 =      # EA41.Pro
                                 # (corr. centrum = 8s23°)

Eqn of argt          2  5 =      # EA41.Ear
                                 # (corr. argt = 11s8;25°)

Var. diam. ND        0  9 =      # EA41.Dpr (corr. argt= 11s8;25;
                                 # Near Dist. as 3s<centrum<9s)

portion var diam.    0  2 =      # Var.diam. * Min.prop. / 60

                   SUBTRACT=     # because corr. argt > 6s
Corr. eqn.argt.      2  7 =      # eqn argt + portion var.diam.
                                 # (plus as Near Dist.)

Sum                  4 17 =      # eqn of centrum
                                 # - corr. eqn. argt (as ADD,SUB)


True place 8'a    4 20 50 =      # mean motus - Sum (SUB,SUB)

motus 8'e          10 23         # for 1301

True place 9'a    5  1 13 =      #  5s 1;10 in Almanach, OK.



------ JUPITER, 1301 July 29, noon, mean motion corrected ------

SUN, mean mot.:   4  4 19  0   # from above, 1301 July 29

---- JUPITER mean motion, Toulouse tables, Par.lat. 16658, 75r-v.
Applying the correction of -1° to the mean motion, cf. canons
§12.
```

```
1296a:           9 15 33 24 =p  # 24": ms; 25" Poulle
4a:              4  1 23 44 =p
June:            0 10  8 13 =p
29d:             0  2 24 34 =t  # 34": ms; 35" TT
--------
Sum:             1 29 29 55 =
Correction:        -1
JUPITER, mean m.:1 28 29 55 =


Argument:        2  5 49  5 =     # mean motus Sun
                                  # - mean motus Jupiter

Apogee:          5 14 30  0       # OK for Jupiter

Centrum:         8 13 59 55 =     # mean motus Jupiter - apogee

                     ADD          # because centrum > 6s
Eqn of centrum:     5  6 =        # EA51.Ece
                                  # (centrum = 8s13;59,55°)

Corr. centrum    8 19  6 =        # centrum + eqn.c.
                                  # [plus as centrum>6s]

Corr. argt       2  0 43 =        # argt - eqn.c.
                                  # [minus as centrum>6s]

Min. prop.            12 =        # EA51.Pro
                                  # (corr. centrum = 8s19;6°)

Eqn of argt         8 42 =        # EA51.Ear
                                  # (corr. argt = 2s0;43°)

Var. diam. ND       0 22 =        # EA51.Dpr
                                  #(corr. argt= 2s0;43°;
                                  # Near Dist. as 3s<centrum<9s)

portion var diam.   0  4 =        # Var.diam. * Min.prop. / 60

                     ADD =        # because corr. argt < 6s
Corr. eqn.argt.     8 46 =        # eqn argt + portion var.diam.
                                  # (plus as Near Dist.)

Sum                13 52 =        # eqn of centrum
                                  # + corr. eqn. argt


True place       2 12 22 =        # mean motus + Sum

Motus 8'e          10 23          # for 1301
-----
true place 9th   2 22 45          # 2s 22;47 in Almanach, OK
```

```
-------- MARS, 1301 July 29, noon, mean motion corrected --------

SUN, mean mot.   4  4 19  0  # from above, 1301 July 29

---- MARS mean motion, Toulouse tables, Par.lat. 16658, 76r-v.
Applying the correction of -3° to the mean motion, cf. canons
§17.

1296a:           3  8 36 37 =p
4a:              1 15 37 11 =p
June:            2  3 55 57 =p
29d:             0 15 11 49 =t   # 49": ms; 48" TT
--------
Sum:             7 13 21 34 =
Correction:        -3
MARS, mean       7 10 21 34 =


Argument:        8 23 57 26 =    # mean motus Sun
                                 # - mean motus Mars

Apogee:          4  1 51  0      # OK for Mars

Centrum:         3  8 30 34 =    # mean motus Mars - apogee

                 SUBTRACT =      # because centrum < 6s
Eqn of centrum:    11 22 =       # EA61.Ece (centrum = 3s8;30,34°)

Corr. centrum    2 27  9 =       # centrum - eqn.c.
                                 # [minus as centrum<6s]

Corr. argt       9  5 19 =       # argt + eqn.c.
                                 # [plus as centrum<6s]

Min. prop.             1 =       # EA61.Pro
                                 # (corr. centrum = 2s27;9°)

Eqn of argt        31 43 =       # EA61.Ear (corr. argt = 9s5;19°)

Var. diam. ND       2 34 =       # EA61.Dpr (corr. argt= 9s5;19°;
                                 # Near Dist. as 3s<centrum<9s)

portion var diam    0  3 =       # Var.diam. * Min.prop. / 60

                  SUBTRACT =     # because corr. argt > 6s
Corr. eqn.argt.    31 46 =       # eqn argt + portion var.diam.
                                 # (plus as Near Dist.)
```

```
Sum                1 13  8 =       # eqn of centrum
                                   # + corr. eqn. argt (SUB,SUB)

True place         5 27 14 =       # mean motus - Sum
                                   # (subtract as SUB,SUB)

+ motus 8'e          10 23         # for 1301

True place 9t      6  7 37         # 6s 7;44 Alman., not favourable.


# If min.prop. = 0, the computed true place would show 40', still
not perfect.



--- VENUS, 1301 July 29, noon, no correction for mean motion ----

VENUS mean mot.    4  4 19  0    # same as SUN's mean motion from
above, 1301 July 29

---- VENUS, argument, Toulouse tables, Par.lat. 16658, 77r-v:

1296a:             1 12 12 55 =p
4a:                6  0 44 36 =p
June:              2 15 12 58 =p
29d:               0 17 52 45 =t   # 45": ms; 46" TT
--------
VENUS, argt       10 16  3 14 =


Argument:         10 16  3 14 =    # see above

Apogee:            2 17 50 10      # OK for Venus

Centrum:           1 16 28 50 =    # mean motus Venus - apogee

                    SUBTRACT =     # because centrum < 6s
Eqn of centrum:       1 24 =       # EA71.Ece
                                   # (centrum = 1s16;28,50°)

Corr. centrum      1 15  5 =       # centrum - eqn.c.
                                   # [minus as centrum<6s]

Corr. argt        10 17 27 =       # argt + eqn.c.
                                   # [plus as centrum<6s]

Min. prop.              43 =       # EA71.Pro
                                   # (corr. centrum = 1s15;5°)

Eqn of argt          17 39 =       # EA71.Ear
                                   # (corr. argt = 10s17;27°)
```

```
Var. diam. FD       0 13 =      # EA71.Dlo
                                #(corr. argt= 10s17;27°;
                                # Far Dist. as 0s<centrum<3s)

portion var diam.   0  9 =      # Var.diam. * Min.prop. / 60

                  SUBTRACT =    # because corr. argt > 6s
Corr. eqn.argt.    17 30 =      # eqn argt - portion var.diam.
                                # (minus as Far Dist.)

Sum                18 54 =      # eqn of centrum
                                # + corr. eqn. argt (SUB,SUB)

True place       3 15 25        # mean motus - Sum (twice SUB)

+ motus 8'e        10 23

True place 9th   3 25 48        # 3s 25;51 in Almanach, good fit




-- MERCURY, 1301 July 29, noon, no correction for mean motion --

Note that the minuta proportionalia are to be treated in a
special way, see Cb151.


MERC. mean mot.  4  4 19  0    # same as SUN's mean motion from
above, 1301 July 29

---- MERCURY, argument, Toulouse tables, Par.lat. 16658, 78r-v:

1296a:           7 19 55 32 =p
4a:              7  8 53 30 =p
June:            0 19  1  3 =p
29d:             3  0  5 40 =t
--------
MERC., argt:     6 17 55 45 =


Argument:        6 17 55 45 =   # see above

Apogee:          6 17 30  0 =   # OK for Mercury

Centrum:         9 16 49  0 =   # mean motus - apogee

                    ADD =       # because centrum > 6s
Eqn of centrum:     2 47 =      # EA81.Ece (centrum = 9s16;49°)
```

```
Corr. centrum    9 19 36 =      # centrum + eqn.c.
                                # [plus as centrum>6s]

Corr. argt       6 15  9 =      # argt - eqn.c.
                                # [minus as centrum>6s]

Min. prop.           +11 =      # EA81.Pro
                                #(corr. centrum = 9s19;36°) PLUS!

Eqn of argt         8 45 =      # EA81.Ear (corr. argt = 6s15;9°)

Var. diam. FD       1 39 =      # EA81.Dlo
                                #(corr. argt= 6s15;9°;
                                # Far Dist. as 9s<centrum<12s)

portion var diam.  +0 18 =      # Var.diam. * Min.prop. / 60

                  SUBTRACT =    # because corr. argt > 6s
Corr. eqn.argt.     9  3 =      # eqn argt + |portion var.diam|.
                                # PLUS from Min.prop.

Sum                 6 16 =      # - eqn of centrum
                                # + corr. eqn. argt (ADD,SUB)

True place       3 28  3 =      # mean motus - Sum
                                # (subtract as ADD < SUB)

+ motus 8'e        10 23        # 1301

True place 9th   4  8 26        # 4s 8;37 Alman., bad fit


# Calculation checked again, no errors found in arithmetic,
signs, or interpolated values. Mean motion values not checked
again but should be correct.
```

# Tables: 1309 April 20, etc.

```
Sample of values, to be checked from the Toulouse Tables. "q"=
Par.16201, 195v; "v"=Vat.4572,97v.

Date chosen arbitrarily: 1309 Apr 20, noon;

(for Saturn) 1309 Apr 15, noon (this date has an un-rounded
value);

(for Moon) 1309 Apr 20, noon + 6h39m (as the preceding mean
conjunction was on Apr 10 + 6h + 39m).

Motus 8'e sphere: 10°30' for 1309. qv

Sun:                        Tau  7;45 =  1s  7;45  qv
Moon (+6h39m):              Vir 15;11 =  5s 15;11  qv
Saturn (Apr 15, Retr.):     Sgr  5;51 =  8s  5;51  qv
Jupiter:                    Aqr 10;35 = 10s 10;35  qv
Mars:                       Aqr  6; 2 = 10s  6; 2  qv
Venus:                      Psc 27;31 = 11s 27;31  qv
Mercury:                    Ari 26;52 =  0s 26;52  qv
Caput:                      Vir 13;40 =  5s 13;40  qv
Latitudo lunæ:                  +0;10 qv

Media coniunctio: 10d 6h 39m; medius lunae 0s 16;9; argm. lunae
4s 27;26; buth solis 2'26"; buth lunae 35'27". qv

Media oppositio: [...]

CHECKMARKS FOR MEAN MOTION VALUES: p = Poulle 1994; t = Toledan,
Pedersen 2002; "=" = checked from Vat. 4572.

For other values, "=" means that the figures have been re-
checked.



---- SUN: 1309 Apr 20, noon ----

1296a:          11  5 30 57 =p
12a:            11 29 55 22 =p
March:           1  0 33 14 =p
20d:               19 42 43 =t
--------
Mean motion:     0 25 42 16 =

Apogee           2 17 50 10 =  # to be subtracted, Cb141a

Argt:           10  7 52  6 =  # mean motus - apogee
```

```
Eqn:                  1 32  5 =  # EA01 (argt=10s7;52,6)
                                 # to be added
                                 # since argt > 6s, Cb141b
--------
True:               0 27 14 21 =  # mean motus + eqn

Motus 8'ae:          10 30 =
--------
Place:              1  7 44 =     # 1s7;45 in Almanach, OK



---- MOON: 1309 Apr 20, noon + 6h + 39m ----

-- Sun, mean motion
Sun m.m., noon      0 25 42 16 =      # from just above
6h:                 0 14 47 =t
24m:                0  0 59 =t
15m:                0  0 37 =t
--------
SUN, mean m.:       0 25 58 39 =


-- Moon, mean motion
1296a:              1  9 57 53 =p
12a:                5  1 58  0 =p
March:              1 18 28  1 =p
20d:                8 23 31 38 =t
6h:                 0  3 17 39 =t
24m:                0  0 13 11 =t # from hour value, shifted
15m:                0  0  8 14 =t # ditto for the rest
--------
MOON, mean m.  4 27 34 36 =

-- Moon, mean argument
1296a:             10  4  0 25 =p
12a:                0 23 49 11 =p
March:              1 15  0 52 =p
20d:                8 21 17 59 =t
6h:                 0  3 15 59 =t
24m:                0  0 13  4 =t
15m:                0  0  8 10 =t
--------
MOON, mean argt   9  7 45 40 =


Elongation          4  1 35 57 =    # Moon m.m. - Sun m.m.

Centrum moon        8  3 11 54 =    # 2 * elongation,
                                    # double elongation

Eqn of centrum       13  7 =        # EA11.Ece (centrum=8s3;11,54)
```

```
Min. prop.            41 =       # EA11.Pro (centrum=8s3;11,54)

Corr. argt       8 24 39 =       # argt moon - eqn of centrum
                                 #(minus as centrum>6s)

Eqn of argt         5  1 =       # EA11.Ear (corr. argt=8s24;39)

Var.diam.           2 38 =       # EA11.Dbr (corr.argt=8s24;39)

portion var.diam.   1 48 =       # var.diam. * min.prop. / 60

corr. eqn argt      6 49 =       # eqn argt + portion var.diam.

true place       5  4 24 =       # Moon m.m. + corr. eqn argt
                                 #  (add as Moon m.a.>6s)
----
motus 8'e          10 30

Place            5 14 54 =        # 5;15,11 in Alm.,
                                  # 17' greater than this



------- SATURN, 1309 Apr 15, noon, mean motion corrected -------

---- SUN mean motion
1296a:          11  5 30 57 =p
12a:            11 29 55 22 =p
March:           1  0 33 14 =p
15d:             0 14 47  2 =t
--------
SUN mean mot.:   0 20 46 35 =


---- SATURN mean motion, Toulouse tables, Par.lat. 16658, 74r-v.
Applying the correction of +1;15° to the mean motion, cf. canons
§12.

1296a:           2 21 27 46 =p
12a:             4 26 38 23 =p
March:           0  1  2 14 =p
15d:             0  0 30  7 =t
--------
Sum:             7 19 38 30 =
Correction:        +1 15
SATURN mean mot: 7 20 53 30 =


Argument:        4 29 53  5 =   # mean motus Sun - mean motus
Saturn

Apogee:          8  0  5  0     # OK Saturn
```

```
Centrum:         11 20 48 30 =   # mean motus Saturn - apogee

                      ADD =      # because centrum > 6s
Eqn of centrum:      0 59 =      # EA41.Ece
                                 # (centrum = 11s20;48,30°)

Corr. centrum    11 21 48 =      # centrum + eqn.c.
                                 # (plus as centrum >6s)

Corr. argt        4 28 54 =      # argt - eqn.c.
                                 # (minus as centrum >6s)

Min. prop.             60 =      # EA41.Pro
                                 # (corr. centrum = 11s21;48°)

Eqn of argt          3 32 =      # EA41.Ear
                                 # (corr. argt = 4s28;54°)

Var. diam. FD        0 12 =      # EA41.Dlo
                                 #(corr. argt= 4s28;54;
                                 # Far Dist. as 9s<centrum<12s)

portion var diam.    0 12 =      # Var.diam. * Min.prop. / 60

                      ADD =      # because corr. argt < 6s
Corr. eqn.argt.      3 20 =      # eqn argt - portion var.diam.
                                 # (minus as Far Dist.)

Sum                  4 19 =      # eqn of centrum
                                 # + corr. eqn. argt (as ADD, ADD)


True place 8'a    7 25 13 =      # mean motus + Sum (ADD, ADD)

motus 8'e           10 30

True place 9'a    8  5 43        # 8s 5;51 in Almanach,
                                 # not a good fit.


# Could it be that the date is really Apr 20? Then the mean motus
would be about 10' greater. -- No, Saturn is retrograde.



------ JUPITER, 1309 Apr 20, noon, mean motion corrected ------

SUN, mean mot.:   0 25 42 16 =   # from above, 1309 Apr 20
```

```
---- JUPITER mean motion, Toulouse tables, Par.lat. 16658, 75r-v.
Applying the correction of -1° to the mean motion, cf. canons
§12.

1296a:           9 15 33 24 =p   # 24": ms; 25" Poulle
12a:             0  4 11 13 =p
March:           0  2 34 33 =p
20d:             0  1 39 42 =t   # 42": ms; 43" TT
--------
Sum:             9 23 58 52 =
Correction:        -1
JUPITER, mean m.:9 22 58 52 =


Argument:        3  2 43 24 =     # mean motus Sun
                                  # - mean motus Jupiter

Apogee:          5 14 30  0       # OK for Jupiter

Centrum:         4  8 28 52 =     # mean motus Jupiter - apogee

                  SUBTRACT =      # because centrum < 6s
Eqn of centrum:     4 14 =        # EA51.Ece
                                  # (centrum = 4s8;28,52°)

Corr. centrum    4  4 15 =        # centrum - eqn.c.
                                  # [minus as centrum<6s]

Corr. argt       3  6 57 =        # argt + eqn.c.
                                  # [plus as centrum<6s]

Min. prop.            34 =        # EA51.Pro
                                  # (corr. centrum = 4s4;15°)

Eqn of argt        11  2 =        # EA51.Ear
                                  # (corr. argt = 3s6;57°)

Var. diam. ND       0 31 =        # EA51.Dpr
                                  #(corr. argt= 3s6;57°;
                                  # Near Dist. as 3s<centrum<9s)

portion var diam.   0 18 =        # Var.diam. * Min.prop. / 60

                     ADD =        # because corr. argt < 6s
Corr. eqn.argt.    11 20 =        # eqn argt + portion var.diam.
                                  # (plus as Near Dist.)

Sum                 7  6 =        # - eqn of centrum(less)
                                  # + corr. eqn. argt


True place      10  0  5 =        # mean motus + Sum
                                  # (add as ADD greater)
```

```
Motus 8'e           10 30
-----
true place 9th   10 10 35          # = same as in Almanach



-------- MARS, 1309 Apr 20, noon, mean motion corrected --------

SUN, mean mot.   0 25 42 16 =  # from above, 1309 Apr 20

---- MARS mean motion, Toulouse tables, Par.lat. 16658, 76r-v.
Applying the correction of -3° to the mean motion, cf. canons
§17.

1296a:           3  8 36 37 =p
12a:             4 16 51 34 =p
March:           0 16 14 43 =p
20d:             0 10 28 51 =t   # 51": ms; 50" TT
--------
Sum:             8 22 11 45 =
Correction:        -3
MARS, mean m.:   8 19 11 45 =


Argument:        4  6 30 31 =   # mean motus Sun
                                #  - mean motus Mars

Apogee:          4  1 51  0     # OK for Mars

Centrum:         4 17 20 45 =   # mean motus Mars - apogee

                 SUBTRACT =     # because centrum < 6s
Eqn of centrum:     8 21 =      # EA61.Ece
                                # (centrum = 4s17;20,45°)

Corr. centrum    4  9  0 =      # centrum - eqn.c.
                                # [minus as centrum<6s]

Corr. argt       4 14 52 =      # argt + eqn.c.
                                # [plus as centrum<6s]

Min. prop.            37 =      # EA61.Pro (corr. centrum = 4s9°)

Eqn of argt        41  1 =      # EA61.Ear (corr. argt=4s14;52°)

Var. diam. ND       5 54 =      # EA61.Dpr (corr. argt= 4s14;52°;
                                # Near Dist. as 3s<centrum<9s)

portion var diam.   3 38 =      # Var.diam. * Min.prop. / 60
```

```
                     ADD        # because corr. argt < 6s
Corr. eqn.argt.    44 39 =      # eqn argt + portion var.diam.
                                # (plus as Near Dist.)

Sum                36 18 =      # - eqn of centrum
                                # + corr. eqn. argt (SUB,ADD)

True place 8th   9 25 30 =      # mean motus + Sum
                                # (add as ADD > SUB)

+ motus 8'e        10 30

True place 9th  10  6  0        # 10s 6;2 Almanach, OK



---- VENUS, 1309 Apr 20, noon, no correction for mean motion ---

VENUS, mean mot. 0 25 42 16 =  # same as SUN's mean motion from
above, 1309 Apr 20

---- VENUS, argument, Toulouse tables, Par.lat. 16658, 77r-v:

1296a:           1 12 12 55 =p
12a:             6  2 13 49 =p
March:           0 19  6 44 =p
20d:             0 12 19 50 =t    # 50": ms; 51" TT
--------
VENUS, argt:     8 15 53 18 =


Argument:        8 15 53 18 =   # see above

Apogee:          2 17 50 10     # OK for Venus

Centrum:        10  7 52  6 =   # mean motus Venus - apogee


                    ADD =       # because centrum > 6s
Eqn of centrum:     1 32 =      # EA71.Ece (centrum = 10s7;52,6°)

Corr. centrum   10  9 24 =      # centrum + eqn.c.
                                # [plus as centrum>6s]

Corr. argt       8 14 21 =      # argt - eqn.c.
                                # [minus as centrum>6s]

Min. prop.           38 =       # EA71.Pro
                                # (corr. centrum = 10s9;24°)

Eqn of argt        40 40 =      # EA71.Ear
                                # (corr. argt = 8s14;21°)
```

```
Var. diam. FD       0 43 =      # EA71.Dlo
                                #(corr. argt= 8s14;21°;
                                # Far Dist. as 9s<centrum<12s)

portion var diam.   0 27 =      # Var.diam. * Min.prop. / 60

                  SUBTRACT      # because corr. argt > 6s
Corr. eqn.argt.    40 13 =      # eqn argt - portion var.diam.
                                # (minus as Far Dist.)

Sum               1  8 41 =     # - eqn of centrum
                                # + corr. eqn. argt (ADD,SUB)

True place 8th   11 17  1 =     # mean motus - Sum
                                # (subtract as ADD < SUB)

+ motus 8'e        10 30

True place 9th   11 27 31 =     #  = same as in Almanach




-- MERCURY, 1309 April 20, noon, no correction for mean motion --

Note that the minuta proportionalia are to be treated in a
special way, see Cb151.


MERC., mean mot. 0 25 42 16  # same as SUN's mean motion from
above, 1309 Apr 20

---- MERCURY, argument, Toulouse tables, Par.lat. 16658, 78r-v:

1296a:            7 19 55 32 =p
12a:              9 26 40 31 =p
March:            3  6 18 28 =p
20d:              2  2  8  3 =t
--------
MERC., argt:    10 25  2 34 =


Argument:       10 25  2 34 =   # see above

Apogee:          6 17 30  0 =   # OK for Mercury

Centrum:         6  8 12 16 =   # mean motus Mercury/Sun - apogee

                     ADD =      # because centrum > 6s
Eqn of centrum:     0 26 =      # EA81.Ece (centrum = 6s8;12,16°)
```

```
Corr. centrum     6  8 38 =       # centrum + eqn.c.
                                  # [plus as centrum>6s]

Corr. argt       10 24 37 =       # argt - eqn.c.
                                  # [minus as centrum>6s]

Min. prop.           +41 =        # EA81.Pro
                                  # (corr. centrum = 6s8;38°) PLUS!

Eqn of argt         9 27 =        # EA81.Ear
                                  # (corr. argt = 10s24;37°)

Var. diam. ND       0 33 =        # EA81.Dpr
                                  # (corr. argt= 10s24;37°;
                                  # Near Dist. as 3s<centrum<9s)

portion var diam.  +0 23 =        # Var.diam. * Min.prop. / 60

                  SUBTRACT =      # because corr. argt > 6s
Corr. eqn.argt.     9 50 =        # eqn argt + |portion var.diam|.
                                  # PLUS from Min.prop.

Sum                 9 24 =        # - eqn of centrum
                                  # + corr. eqn. argt (ADD,SUB)

True place        0 16 18 =       # mean motus - Sum
                                  # (subtract as ADD < SUB)

+ motus 8'e        10 30

True place 9th    0 26 48         # 0s 26;52 in Almanach
```