Alkhwarizmi's astronomical Rules:
Yet Another Latin Version?

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§1. The manuscript Oxford Merton Coll. 259 ("Oo" in the following; early 13th cent.) contains a set of Latin canons[1] adapted for the Toledan Tables,[2] mainly independent of the two collections of rules commonly found.[3] Similar canons, in other witnesses, were treated by Zinner 1936, see §6-7 below. The present text seems to be more primitive than the rules known till now. Indeed, whereas the other texts more or less follow some conventional ordering, ours is an obvious conglomerate of disparate canons on older tables, juxtaposed without much editing; an analysis can be found in §4. In particular, Oo preserves some sections that are in fact invalid for the Toledan tables and were eliminated or re-handled in the rest of the Latin tradition.

One such section ("Part A" in §4) consists of rules that may be quite a good approximation to the "original" canons of Alkhwarizmi for his astronomical tables (9th cent.). These are not known in Arabic, nor from elsewhere in any coherent form. The main source for their extent and wording is the commentary of Ibn Almuthanna (10th cent.?).[4] Ibn Almuthanna's text is not known in Arabic either, but it is available in two Hebrew versions edited by

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1: ff.76r-89v, incipit "Scientia inveniendi radices. Cum volueris scire qua die ingreditur unusquisque mensium Arabum". Headed "Canones Arzakel" in a 15-16th-c. English hand. Listed in Steinschneider 1884, p.(80) no.11; Toomer 1968, p.167 no.97. - I have seen a microfilm of the manuscript, kindly supplied by Merton College. It is written in different hands of the early 13th century. It also contains a set of Toledan tables (2r-39v), plus a number of astronomical and astrological writings. Many of these are connected with John of Seville (42r-75v, 94v-99v), but our text itself shows no evidence of such an affinity. Some secondary notes on f.76r mention the years AH 590 and 639 (about AD 1193 and 1242); there seems to be nothing else to suggest a date.

2: In any case the tables in question used Toledo for their meridian, see §6 below. -- The collection known as the "Toledan Tables" occurs in several Latin versions that differ considerably (see Toomer 1968; an investigation by the present writer is forthcoming). One such fairly archaic version does occur in ms. Oo (see preceding note); but the relationship between canons and tables cannot be discussed on this occasion.

3: "Cb" = "Quoniam cuiusque actionis", see §3, and "Ca" = "Scito quod annus lunaris", mainly unpublished (extract printed by Millás 1942, 253-55).

4: Other sources, and other versions of Alkhwarizmi: see §8 below.

Goldstein 1967, and in Hugo Sanctallensis' Latin translation edited by Millás-Vendrell 1963, not interdependent with the Hebrew versions.[1]

Our Part A follows Alkhwarizmi's canons as rendered by Ibn Almuthanna. I have compared it with Goldstein's English translation (for want of Hebrew), supplemented with the Hugo version[2]. All or nearly all the fragments of Alkhwarizmi found in Ibn Almuthanna (including both the lemmas and the text he quotes expressly within his interpretation) turn out to be recognizable in our text, and mainly in the same order. Part A and Goldstein are also often similarly worded:[3] thus, no matter how many translations may have intervened between them, all of them must have been fairly literal. There are exceptions to these observations, mentioned in §10. Notably, neither Part A nor Part B contain any rules for planetary motions and equations.[4]

In §11 I print a coherent piece from Part A, mostly treating of eclipses, and ending where our evidence from Ibn Almuthanna leaves off. Most of this piece is no doubt similar to the text Ibn Almuthanna believed to be by Alkhwarizmi. Several passages are, however, ignored by Ibn Almuthanna, and some of these may be later additions; but if such additions are to be identified, our text must be compared to other parallel sources.[5] The purpose of this print is simply to facilitate such comparisons, and commentary is included only as far as it concerns the constitution of the text.

§2. The rest of the text ("Part B" in §4) was probably compiled in order to supplement Part A with rules necessary for some version of the Toledan Tables. It seems to have a kernel of eclipse canons conventionally ordered, but apart from this, it shows no clear-cut structure. The compilation may have been done in several stages, from disparate material: indeed, as is seen from §4, Part B shows features from Albattani mixed with unidentified texts, and with many overlaps and repetitions. In §6 I shall list the few pieces of

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1: Shown by Goldstein (1967, 12). -- I ignore the problem of how far the text Ibn Almuthanna saw was authentic (cf. §10), and whether he had it from Alfargani (Goldstein p.5-6).

2: Goldstein's edition is justly acclaimed (cf., e.g., Toomer, DSB 7, 364b), but both his versions are incomplete; mostly I have adduced the Hugo version without notice. -- Millás's edition, if nothing else (cf. Toomer, *loc.cit.*), seems to be fairly complete, and to render the lemmas well. For detailed wording I have also consulted the text in Cambridge, Gonv. & Caius 456, p.1-169.

3: The Hugo version is more difficult to compare because of Hugo's mannered Latin.

4: Planetary rules do occur elsewhere in Oo, thus at 53r-55rb (mean motion, equations, retrogradation, mainly from the canons Ca, in different hands, one of which may be the same as in our text); 67r (equations, in a hand contemporary with our scribe).

5: Such as those listed in §8, and to the Sanskrit sources; I only adduce the *Khandakhadyaka* once or twice by way of example.

evidence that bear on the compilation, trying to make it plausible that most of the collection had been made before our text was translated into Latin.

One of the common sets of canons, "Quoniam cuiusque" (Cb), consists of rules that are generally similar to Albattani or to Alkhwarizmi. Our text (either Part A or Part B) turns out to furnish close counterparts to most of these rules, while showing a simpler style, likely to be closer to the Arabic origins. Some comparisons can be found in §9, but for the present purpose I do not enter into the general question of the genesis of the canons,[1] nor into the question of their correspondence with any particular set of tables.

§3. Abridgments:

Batt: Albattani, ed. Nallino, by chapter.
Ca99: paragraph in my transcript of "Scito quod annus", to be published later.
Cb99: paragraph in the canons "Quoniam cuiusque", ed. F.S. Pedersen 1987.
Hugo: Ibn Almuthanna in the Latin version of Hugo Sanctallensis, from the print by Millás-Vendrell, occasionally supplemented from Cambridge Gonv. & Caius 456 p.1-169.
Investigantibus: the canons "Invv. astronomiam", ed. F.S. Pedersen 1990.
Maslama: the canons of Maslama Almajriti in Adelard of Bath's Latin version, edited by Suter 1914.
Oo999: paragraph in my transcript of ms. Oo. This numbering is not meant to be standard: the cognate canons (§7) show similar rules in different arrangements. It may be discontinued in future treatments.
Q99: Ibn Almuthanna, (q)uestion-number according to Goldstein's English translation (the "Michael" version). Page references are to Goldstein. Passages that are not in Goldstein's lemmas but are supplemented from Ibn Almuthanna's interpretations or from the Hugo version are designated as "Q99a", etc. -- Where the version is important, I specify it as Hugo or Goldstein.

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1: This includes their relation to Ibn Said and to Azarchel, for which see the discussion by Richter-Bernburg 1987, 386-87, and §9 below.

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Zinner, E.: 1936, "Die Tafeln von Toledo (Tabulae Toletanae)", Osiris 1, 747-774.

§4. The following table summarizes the contents of our canons; for the texts compared see §3. Agreement is indicated where the texts, to judge from phrasing and structure, could be different translations or adaptations of the same text. It is also noted whether the passages in question occur in the manuscripts Mc, Lx Pz Mb; for these witnesses see §7 below. Parentheses indicate cases where texts show much the same contents and structure though they are differently stated; or where manuscripts are partly present. Agreement in method only has not been recorded.

PART A.	Alkhwarizmian		Q	Batt	Cb	Cognates
		Chronology:				
001-014	76r-v	Calculation	1-15	32	(15-32)	Mc (Pz Mb Lx)
015-024	76v-77r	By tables	(17a-18)	-	(33-44)	Mc
025-030	77r	Era & Christian	-	-	45-46	Mc Pz Mb Lx
031	77r	Era	-	-	-	-

		Trigonometry:	Q	Batt	Cb	Cognates
032-040	77v	Kardagas 1	(36)	-	52-59	Mc Pz Mb Lx
041-048	77v-78r	Sine table	-	(3)	60-66	Mc
049-055	78r	Latitude, geo.	38-40	(14)	67-71	Mc (Pz Mb Lx)
056-065	78v	Right asc.	(41-42)	(5)	72-78b	Mc
066-072	78v	Oblique asc.	(43)	-	79-85a	Mc Pz
073-075	78v-79r	same, fgt.?	-	(13?)	(82-84)	Mc
076-079	79r	same, shadow 1	(44)	(13)	85b-87	Mc
080	79r	same, shadow 2	-	-	88?	Mc
081-086	79r-v	same, table	-	(13)	89-95	Mc
087-088	79v	same, calcul.	45	-	96-97	Mc Pz
089-102	79v-80r	Hours; Ascend.	(46-50)	(13,16)	98-112	Mc (Pz)
103-107	80r	Ascendent 2	(51)	-	112-115	-
108-110	80r	Houses 1	52-53	(35)	116a-b	Mc
111-112	80v	Houses 2	-	-	(116a-b?)	Mc
113-116	80v	Hours 2	(53?)	-	119-121	-
117-119	80v	Shadow, calc.	54-55	(10)	122-124	Pz Mb Lx
120-122	80v	Shadow, table	-	(10)	125-126	-
		Planetary:				
123-125	81r	Latitudes	56-57	-	-	-
126	81r	Velocities	57?	-	-	Pz Mb Lx
127-133	81r-v	Visibility	61-65	-	-	-
		Eclipses:				
134	81v	Diametres	66	-	-	Pz Mb Lx
135-140	81v	True syzygy	58-60	-	-	-
141-149	81v-82r	Lunar eclipse	67-70	(43)	-	-
150-153	82r-v	same, figure	70	43	(207)	-
154	82v	same, colours	70	-	-	-
155-172	82v-83r	Solar eclipse	71-83	-	-	-
173	83v	same, figure	84	-	-	-
		Various:				
174-180	83v-84r	Revolutions	85-87	-	225-229	Pz Mb Lx
181-205	84r-v	Kardagas 2	(35)	-	236-260	-
206-207	84v	Day-arc of stars	-	(18-19)	230-231	Pz Mb Lx
208-212	85r	Time of night	88-93	(20-21)	232-235	-

Mantissa to Part A?

213-215	85r	Projections	-	-	211-213	-
216	85r	Nodes, list	-	-	166?	-

PART B.	Additions, mainly Albatenian		Q	Batt	Cb	Cognates
217-218	85r	Declination	-	(4)	161-162	-
		Planetary:				
219-220	85r	Latitude, moon	-	38	163-164	-
221-227	85r-v	Latitudes 1	-	47	-	Mc
228-233	85v	Visibility 1	-	48	214-220	Mc Pz Mb Lx
234		Elevation	-	-	223a?	Mc
235-236	86r	*Eighth sphere*	-	-	221-222	Pz Mb Lx
		Eclipses:				
237-246	86r	True syzygy 1	-	42	170-175	Mc Pz Mb Lx
247-249	86r	Parallax 1	-	(39)	182b-183	Mc Pz Mb Lx
250-262	86v	Solar eclipse 1	-	(44)	186-192	Mc Pz Mb Lx
263-268	86v-87r	same, figure	(84)	44	199	Mc Pz Mb Lx
269-274	87r-v	Lunar eclipse	-	(43)	200-204	Mc Pz Mb Lx
275-284	87v-88r	same, figure	-	43	(207-208b)	Mc Pz Mb Lx

Mantissa, mainly eclipses

285-288	88r	True syzygy 2	-	42; H	(177-178)	Mc
289-294	88r-v	Diametres	-	(43)	193-198	Mc Pz Mb Lx
295-297	88v	Parallax 2 (= Oo247-249)				
298-307	88v-89r	Parallax 3	-	(39)	179a-185	Mc
308-312	89r	Visibility 2	-	41	-	Mc

Mantissa, Alkhwarizmian

313-315	89r	Latitudes 2	-	-	165-166	Mc
316-320	89r-v	Solar eclipse 2 (= Oo160-165)				Mc

§5. Our text is obviously a translation, presumably from the Arabic. It seems literal throughout, in a simple style, and with a fairly uniform terminology. Peculiarities of the type "et *quod* fuerit, adde *eum* super..." (whether Arabisms or due to an intermediary language) are frequent in Part A as well as in Part B. Thus conceivably one person made the whole translation.

Generally, the text shows few Latin adaptations. The only obvious ones are the canons for Christian chronology,[1] and perhaps for the Spanish Era, plus the following remark:

1: Even the Christian element in Oo025-030 may be additional, see note to §10.

(Oo033, 77v, also in Mc Pz Mb Lx; cf. Cb53:) Operab(eris) autem ita: accipies unicuique signo duas (duos Oo) kardageth et omnibus 15 gradibus unam kardagam. Quid sit autem kardaga, exponamus. "Kardaga" nomen Syriacum est, et in Latino sonat "abscisio"; cuius pluralitas est "kardageth" id est "abscisiones".[1]

So the details of the text seem to have been left fairly untouched in translating and in any later revisions. Still, the translator may have compiled the text while translating, or he may have taken it over ready-made from the Arabic, touching it up slightly. The next paragraph will try to show that the latter alternative is more probable.

§6. There are no datings within the context, and pretty little evidence for location and authorship except what may have been taken over from the texts compiled. The information was listed by Zinner 1936 p.765-66 from the cognate canons in ms. Mc and others (see §7), and will be briefly re-considered below.

In Part A, the only distinctive passages seem to be the following:

(Oo058, 78v, also in Mc; cf. Cb74:) ... accipies declinationem totam -- quae est, secundum quod narravit *Ptolomaeus in Almagesti*, 23 graduum et quinquaginta unius minuti, et secundum quod invenit *Yahie ben Abimansor* (Mc; lahieben ab imase Oo) per ammirationem aspectus et considerationis 23 graduum et 33 minutorum (Oo:) quod est verius apud nos, quia prima<m> novimus rumore (per r-em Oo.pc) et hanc didicimus per considerationem -- (Oo Mc:) accipe igitur declinationem totam ...

(Oo081, 79r, also in Mc; cf. Cb89:) Cumque volueris scire ascensiones gradus alicuius quem volueris, accipe ab initio eiusdem signi in lineis numeri usque in gradum quem volueris, et accipe quod in directo eius inveneris ex gradibus atque minutis. Et quod fuerit erunt ascensiones quae sunt ab initio arietis usque in ipsum gradum in civitate +*aselmah*+ (Mc; haselmah Oo) quae dicitur *Bagdeth* (Mc; hageleth Oo), quia super hanc constitui tabulam.

This presupposes a table of oblique ascensions for single degrees, not confirmed from Ibn Almuthanna. Zinner (1936, 766) tentatively assigns such a table to Albattani (Nallino II p.67) or to Yahya ibn Abimansur, Alkhwariz-mi's contemporary, mentioned in the first passage. If "aselmah" could be read as ash-Shamasiya, the quarter of Baghdad where Yahya founded an observa-tory for Al-Mamun,[2] this may speak for his authorship without excluding Alkhwarizmi's.

1: The latest interpretation of the term, from Sanskrit, is in Mercier 1987, 107.

2: Observatory, e.g., Kennedy 1956, p.132 no.51.

The rest of the evidence is confined to Part B.

> (Oo242, 86r, also in Mc Pz Mb Lx; cf. Cb172b:) ... eruntque horae aequales ad horam
> coniunctionis vel impletionis post medium diem eiusdem diei in media civitate *Aracca*
> (tua Oo.pc), ea scilicet condicione ut dies cum noctibus sint medii. (Oo243, cf.Cb173:)
> Si autem volueris reddere eos diversos ... <eruntque horae coniunctionis vel
> impletionis> certissimae in civitate *Aracca* (araca Oo).
>   (Oo244) Ex quibus minues III'es horas aequales et duo minuta unius horae, et
> quod remanserit erit post medium diem civita<ti>s *Toleti*.
>   (Oo244a) Sed scito quod liber iste constitutus sit super medium diem civitatis
> *Toleti*, et ideo non erit tibi necesse minuere has horas (h.has Oo).
>   (Oo244b) Et cum feceris coniunctionem vel impletionem cum hoc libro, qui
> (quod Oo) est *Albateni*, et feceris eam cum canone *Alchoahrizmi* (algoarzmii Oo),
> exieritque una earum (eorum Oo) post aliam per unam horam vel plus, <re>itera
> quae suspicaveris ex eis errasse. Si vero fuerit inter eos minus una hora, erit hoc
> possibile, si deus voluerit.

Oo242-43 is a paraphrase of Albattani c.42 (p.94,32-34.19-21; 95,3-8 Nallino), keeping his location at Ar-Raqqah. It probably accompanied an original set of Albatenian tables that was used for Toledo: this state of affairs is attested by Oo244. On the other hand, Oo244a shows a later stage where tables had been introduced that were specifically Toledan: this note was probably made by the compiler of our text.

The note Oo244b is dubious. It was written by an Arab, to judge from the concluding phrase. He may have been a Toledan: at least he is likely to have thought of a reduction such as the one described in Oo244, to make possible the comparison he suggests. He knew the Albattani tables ("hoc libro") for what they were. He knew, too, of one other work on eclipses attributed to Alkhwarizmi, but he seems to imply that it was not in "hoc libro"; so probably he was earlier than the compiler, perhaps the same as the author of Oo244.

Thus the reference to Alkhwarizmi need not pertain to our Part A as it stands, and does not serve to authenticate it. It remains a question why someone conveniently kept the Alkhwarizmian eclipse rules in Part A, needed for the comparison with Albattani, whereas he had the presence of mind to discard the planetary equation rules.

> (Oo250, 86v, also in Mc Pz Mb Lx; cf. Cb186:) Cum volueris scire eclipsim solis, aequa
> coniunctionem ... quia latitudo lunae erit tunc septentrionalis. Et si [non] fuerit aliter,
> non erit eclipsis in climate *Cordubae* (-bie Oo) vel in his regionibus quarum latitudo
> fuerit prope latitudinem eius <**?> ab oriente in occidentem nisi res modica...
>   (Oo251, cf. Cb187:) ...et scito horam coniunctionis aequatam per diversitatem
> dierum cum noctibus suis in *Corduba* vel in regione quam volueris...

(Oo257, cf. Cb189:) Post haec aspice minuta diversitatis aspectus in latitudine (-nis Oo), et est semper meridiana in *Corduba* et in omni regione, cuius latitudo fuerit plus XXIIII gradibus.

This passage on solar eclipses is not much like Albattani except for the treatment of parallax. Because of the reference to Cordova, Zinner (1936, 766) assigned the corresponding tables to Maslama's version of Alkhwarizmi.

A fairly untouched piece of Albattani, with an ascription, is:

(Oo308, 89r, also in Mc; cf. Albatt. c.41, Nallino p.86 l.37+:) Narravit *Albateni* in opere visionis novae lunae, ut scias locum lunae et latitudinem eius; post haec facies diversitatem aspectus lunae in longitudine et latitudine, et scies locum eius visibilem...

All this once more serves to show the unevenness of Part B. The allusions both to Cordova and to Toledo, and the scarcity of Latin references, may still suggest that the compilation was made in a Hispano-Arabic environment, in accordance with the common opinion that a form of the Toledan Tables had such an origin.[1]

§7. *Cognate versions.*

Four more manuscripts (and a number of fragments) have most of their rules in common with our text. The manuscripts are:

Mc: München B.Sb., Clm 18927, 35r-45r
Pz: Paris BN, lat. 16208, 92v-100ra
Mb: München B.Sb., Clm 13021, 31vb-68va
Lx: Leiden B.Ru., BPL 191 E, 141r-156v.

The following remarks are meant to make it plausible that Oo has the priority over the cognates; of these, Mc is generally closest to Oo, as will appear.

The cognate versions appear as selections from a text like Oo (see the summary in §4), re-arranged, and with certain additions, see below. The wording of the rules can mostly be collated with Oo; only in a few cases can there be any suspicion that it has been emended or re-translated from an Arabic exemplar. There are some further attempts at adaptation to Latin affairs: thus two chronological canons for the years of Alexander[2] have been

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1: E.g., Zinner 1936, 763.
2: Oo005, Oo012.

furnished with notes on Christian years. Mc gives part of these notes interlinearly, the rest have them in context.

The omissions in the cognate versions, as appears from §4, mostly concern Part A, and comprise such Alkhwarizmian canons as were made superfluous by the additions in Part B. Generally, Mc does not omit much more than this, whereas the rest are more selective; on the other hand they keep some rules discarded by Mc, most of them in Part A, plus the rule on the eighth sphere.

The additions are various, but a lot of them are meant to make up for the missing canons on planetary motions and equations. Thus, Mc adds Chapters 7-17 in the wording of Adelard of Bath's translation of Maslama's Alkhwarizmian canons (like Suter's version O).

Of these chapters, Pz Mb Lx keep ch.7-8 (mean motions, solar equations) and ch.13-17 (stations, latitudes),[1] whereas ch.9-12 (equations proper) have been replaced by a set of rules much like Ca95-105 (or Cb143-51). These rules are difficult to place: some of the wording is recognizable in Albattani (ch. 36, 37, 45), in Maslama (ch.10-11), in Ibn Almuthanna's rendering of Alkhwarizmi's own rules (Q28-34), and in the rules of Par.lat.16208 (§8). For all we know, they could be adaptations from Alkhwarizmi, eliminating his peculiar method.

Pz Mb Lx, on their own, add the two prefaces from Cb (Cb1-14 and 127-138b), including the incipit "Quoniam cuiusque", plus lesser pieces such as Cb160, 176-78 (velocities), Cb211-13 (projections), and a few others. The prefaces, at least, are likely to have been composed by Latins, whatever their models.

Mc, on its own, adds a preface "Bonorum omnium formam et scientiarum" (33v-35r; T&K 179). This incorporates a version of Petrus Alfonsi's preface to a set of rules,[2] together with much extra matter. With no more evidence

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1: Noted by Zinner 1936 p.765, from ms. Mb and Mc, and by Toomer from ms. Pz, see Neugebauer 1962, 214 n.24.

2: Printed in Neugebauer 1962, 216-26, from Oxford C.C.C. 283, 143v-144r, together with the set of canons that follow, for which see §8. (Millás-Vallicrosa, "La aportación astronómica de Pedro Alfonso", Sefarad 3 (1943) 65-105, brings a longer version from London BL Arundel 270, not relevant here; text, p.97-105; discussion, p.75-81.) -- The text in Mc consists of: a passage on the place of astronomy in the sciences; the section corresponding to Petrus Alfonsi (as in Neugebauer's print, 143va16-143vb33); lastly, a tract "de terra" on climes, elements, signs, and constellations, ending: (Mc,35r:) "Quoniam vero posita ponendaque temporum ratione clarius habita cognoscuntur, de his et paribus nobis tractare ratio persuasit. -- (Cf. Petrus, 143vb34:) Primus itaque titulus, qui nunc est Latinus *De annis Christi,* erat Arabicus *De annis lunae et mensibus.* Constat namque lunaris annus ex 354 diebus et 5'ta et 6'ta unius diei...", etc., continuing in the canons.

at hand, it is unsafe to speculate on the affinity of these texts; the likely guess
is that Mc has adduced the mixed Petrus text to supplement ours.

The general conclusion is that the bulk of the additions are compositions
by Latin writers, or extracts from known works in Latin, except perhaps some
of the planetary rules. Thus it may be assumed that the cognate versions had
slight, if any, recourse to any Arabic texts.

§8. *Relation of Oo to other versions of Alkhwarizmi's canons.*[1]

The rules revised by Maslama Almajriti and translated by Adelard of Bath
(ed. Suter 1914 and Neugebauer 1962) occur in several versions[2]. They are
structurally much alike. It was said above that the cognate canons in Mc Pz
Mb Lx have incorporated passages verbatim from Suter's "O" version.

None of the text in Oo is worded similarly to Adelard, but some passages
show enough similarity in phrasing and structure to suggest a common textual
source for Oo and Maslama. I have noted the following parallels from Part
A, all of them in the trigonometrical section:

Maslm 23	Sine table	Oo041-045	not in Q
Maslm 24	Latitude, geo.	Oo049-050	Q38
Maslm 25	Right ascensions	Oo056-065	not in Q
Maslm 26a	Oblique asc.	Oo076-077	Q44
Maslm 27	*partes horarum*	Oo093-094	Q47?, banal
Maslm 28-a	Shadow, calc.	Oo117-118	Q54-55

This may be thought to serve as authentication for the pieces of Oo that have
no good parallels in Ibn Almuthanna, especially for the rules on right
ascensions. But the purity of either text is indeterminate; for instance, most
of the pieces mentioned have more or less close parallels in Albattani too.

A few scattered parallels from the tail of Part A, and from Part B, are
inconclusive:

1: A survey of the other sources for the canons is in Haddad & all. 1981, 224-25, cf. Toomer
1964 and 1973, Pingree 1976, 152, and Mercier 1987, 88-102. -- I keep to the sources that
present some coherent text ascribable to Alkhwarizmi, thus ignoring, e.g., the testimonies in
Abraham ibn Ezra (Millás 1947).

2: Version O as opposed to the rest: Suter p.XIII. Toomer (1964, 211b) showed that version
O has referred back to the Arabic text. For an extended treatment of the versions see Mercier
1987, 88-102. -- A version by Robert of Chester (Madrid 10016, 8r-69v; Suter p.XIV; Toomer
1964) is a terminological revision. One of the versions by Petrus Alfonsi is in London, Lambeth
Palace 67, 64r-91v(tables), 92r-95r (rules; Mercier 1987,95, with further references). The rules
include Ch. 7-17 of Version O, plus (92v-94v) the incomplete canons "Dixit Petrus Anfulsus"
treated below.

Maslm 15	Declination	Oo217-18	not in Q
Maslm 19	Nodes, list	Oo216	not in Q
Maslm 31	True syzygy	Oo237	not in Q
Maslm 33	Lunar eclipse	Oo269-272	not in Q

The canons "Dixit Petrus Anfulsus servus Ihesu Christi translatorque huius libri" were mentioned in §7, since an extract of their preface enters into the preamble of the version in ms.Mc. This preface is in Oxford C.C.C. 283, 143v-145r, and in London, Lambeth Palace 67, 92v-94v, with appended canons.[1] The canons are the same in both these witnesses; they were printed from the Oxford manuscript by Neugebauer 1967, 216-26. All of them are chronological, covering the eras of the Arabs, Yazdegerd, Alexander, and Diocletian, and ending imperfectly. This fragment has the same general contents as Ca or Oo, but the ordering and some of the inventory is different from either, so I have not attempted a detailed comparison. Generally, Ca and Oo are closest together.[2]

The canons "Cum volueris invenire locum solis extrahe numerum", in Par.lat. 16208, 2r-3v (tables, 5r-12v), assigned to Alkhwarizmi by Mercier,[3] are probably a translation, and in much the same style as the text of Oo. The rules concern planetary mean motions, longitudes, latitudes, and stations. The canons for latitude show the same text as Oo313-315 (Part B), much like Cb165-66; they use tables as does Maslama ch.17. On the other hand, the latitude canon in Ibn Almuthanna and in Part A (Oo124-25, printed below) is computational and quite differently worded.

Thus, when comparing nothing but the wording of the canons, one finds that the Latin evidence is too scattered or re-handled to offer much support for the text known by Ibn Almuthanna; and one is once again reminded of the general difficulty in using Majriti for a guess at the original rules by Alkhwarizmi (cf., e.g., Neugebauer 1962, 8-9).

Of Arabic sources I have only seen Alhashimi, in the translation of Haddad 1981. A section on chronology, probably from Alfargani's commentary

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1: The text of the London manuscript was kindly communicated to me by Prof. G.J. Toomer.

2: One specific point of similarity between the Petrus canons and Ca is the "more Chotensium Christianorum" (on years of Alexander: Oxford CCC 283, 144va18, Neugebauer p.223), corresponding to "secundum Christianos religionis nostrae" in Ca19 but to nothing in Oo or Cb.

3: 1987, 101. The tables may be meant for Toledo (Mercier, from the meridian used). There is a note on "absis Toletana" (5r, for the sun); other notes, mostly secondary, concern London, Paris, Le Mans, and Troyes.

on Alkhwarizmi, contains four rules rather close to Oo002-005 (Q3-6).[1] --
From elsewhere, Haddad quotes a table with rule purporting to be from the
"Zij al-Sindhind attributed to ... al-Khwarizmi".[2] The table is similar, though
not identical, to Maslama (Suter Tab.2, same as the Toledan table T09). The
rule corresponds to Ca42, Cb48, and to Maslama ch.4, which makes the
attribution pretty safe. For all this, it is absent from Oo.

I have not seen the commentary on Alkhwarizmi by Ibn Masrur[3], nor the
table for projection of rays rendered by Ibn Hibinta,[4] nor the Latin "Tabulae
Iahen"[5]. There is evidence that Herman of Carinthia has translated
Alkhwarizmi;[6] this translation is unidentified. It is hardly the same as our
text, which is far below Herman's usual florid style.

§9. *Relation of Oo to the common canons.*

As is seen from §4, the canons "Quoniam cuiusque" (Cb) have much in
common with our text. The parallels are hardly ever word-for-word: Cb has
a more polished style than Oo, lacking, e.g., the peculiarity noted in §5.[7] A
comparison of Cb with Oo174-212, printed below, suggests that Cb might not
be a re-translation but a revision of our Latin text as it stands; but if our text
is a literal translation, these two possibilities can only be distinguished by
means of a detailed examination, which falls outside the scope of the present
article.

Cb does not depend on any one of the versions considered till now. For
instance, Cb renders sections that are only in Oo, most notably Cb230-60; and
Cb contains a variant of the prefaces only found in Pz Mb Lx (§7), though it
is uncertain which version is paraphrased from the other. See below for the
planetary section.

1: Attribution to Alfargani: Haddad p.229. The rules are on f. 98r23-98v3; 99v21-23; 100r19-22; 100v21-23.

2: Haddad p.231-34, from an Arabic ms. in Istanbul; context not indicated.

3: Indicated by Kennedy / Ukashah 1969, 86 and 96. The one quoted rule ascribed to Alkhwarizmi (p.94, concerning the sine of the radix, cf. Oo124) is "to take the maximum planetary equation, and take half of it, and make it a sine." This is not in Oo124 as it stands now, though Ibn Almuthanna has similar statements in his commentary, see note *ad loc.*

4: Nallino I,312; Suter p.100; cf. Haddad p.323-24. The table is different from Maslama's; it might be like the Toledan table T85, but Suter gives too little detail for comparison.

5: Lemay, DSB 15, 180 no.31; cf. Mercier 1987, 101 with further refs. -- The Samaritan tables indicated by Mercier, *ibid.,* are hardly relevant.

6: Suter 1914, XII; Haskins 1924 p.44.

7: Oo179, printed below, does correspond closely to Cb228. This, however, is not in the older manuscripts of Cb, and is likely to have been introduced via glosses.

The list below, which is meant as a cross-reference to §4, shows what Cb takes over from each part of the Oo version.

Cb1-12	Preface	not in Oo	
Cb13-51	Chronology	(Part A)	badly covered
Cb52-126	Trigonometry	Part A	except Cb117-8 (on T84)
Cb127-60	Planets	not in Oo	
Cb161-64	Lat., Sun & Moon	Part B	
Cb165-66	Lat., planets	Part B	another version is in A
Cb167-69	Mean syzygy	not in Oo	late addition in Cb
Cb170-208b	Eclipses	Part B	except Cb176, 205-6.[1]
Cb209	Star table	not in Oo	
Cb210	Geographical	not in Oo	
Cb211-13	Projections	Part A?	in Mantissa to A
Cb214-20	Apparition	Part B	
Cb221-222	Eighth sphere	Part B	
Cb223a	Elevation	Part B	Cb223b is a late addition
Cb224-29	Revolutions	Part A	
Cb230-35	Day-arc, etc.	Part A	
Cb236-60	Kardagas 2	Part A	

Relatively to Oo, Cb has supplied

> the preface (no doubt composed by a Latin),
> much of the chronological matter (some of which is Christian),
> the rule for the table of houses (absent in the older versions),
> the planetary part (see below),
> the rule for the stellar table,
> the rule for the geographical table.

So Cb is pretty well accounted for in this way. The section on planetary equations (Cb139-160) looks like a paraphrase of a text similar to that of mss. Pz Mb Lx (§7), thus composite of Maslama's canons and an unknown rule.[2]

The connexion of Cb with Cremona (not to speak of Gerard of Cremona)[3] cannot be discussed here. Cremona is mentioned in Cb89 (where the counterpart in Oo has Baghdad, see §6) and in Cb140 (not in Oo; perhaps from Maslama ch.8, in which case the example for Cremona is additional). Oo

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1: Cb179, 182-3 have two versions within Part B; Cb207 has another version in Part A.

2: Similarity to Maslama, noted by Millás Vallicrosa 1943, 49-50. -- Richter-Bernburg (1987, 388-89) considers assigning the planetary tables and the star-catalogue to Ibn Said. The canons may or may not have a different history.

3: Lately, e.g., Richter-Bernburg 1987, 392 n.9b.

does not mention Cremona, nor does any of the cognate versions.[1] So, if it could be shown that Cb is not a fresh translation (see above), then the reference to Cremona would not be due to a translator, thus possibly not to Gerard.

The canons Ca, "Scito quod annus", show a few passages whose wordings are very similar to Oo, as follows:

Ca3-17	chronology	Part A: Oo001-014	(Cb15-32)
Ca33-35	chron., Christ.	Part A: Oo025-030	Cb45-46
Ca47-52	geo latitude	Part A: Oo049-055	Cb67-71
Ca67-70	shadow, table	Part A: Oo120-122	Cb125-26
Ca116-121	latitudes	Part B: Oo221-227	not in Cb
Ca126-133	syzygies	Part B: Oo237-246	170-175
Ca134,136,			
Ca140-3	lunar eclipse	Part B: Oo269-274	Cb200-204
Ca185-188	diameters	Part B: Oo289-294	Cb193-198

As was mentioned in §7, the planetary equation rules Ca95-105 do not have counterparts in Oo, but in the cognate versions and in Cb143-151. All taken together, Ca fits Oo much less well than does Cb, and it may have had independent sources.

§10. *Part A,* as was said, follows Ibn Almuthanna's rendering of Alkhwarizmi's canons, except that Q58-60 and Q61-66 are interchanged, thus making the eclipse section coherent. There are some Latinizing revisions (§5), and the rules for planetary equation are left out (§1). It must be asked whether the text was re-handled in other ways, relatively to Ibn Almuthanna's version.

Some doubt may be had about the sections on chronology and trigono-metry (Oo1-122), which are not very tightly covered by Ibn Almuthanna. As concerns the chronological section, Ibn Almuthanna's silence indicates nothing: much of the text is banal, and would not trigger a commentary in any case. The rules for Christian years[2] may be interpolated.

1: The ascension table for Cremona (T19), common in the manuscripts of the Toledan Tables and often adduced to corroborate this location, does not occur among the Toledan tables found in ms.Oo, nor, e.g., in Cambridge Trinity O.8.34, a particularly archaic version of the Toledan Tables. It does occur in the tables found in ms. Pz (though headed as if for Toledo) and in Mc. Lx lacks tables, and Mb lacks trigonometrical tables. All this may, of course, only testify to the loose connexion between the canons and the tables.

2: Oo025-030. In Mc Oo, the text begins, "Cum volueris extrahere annos Arabum de annis *aerae vel annis* (*om.*Mc) domini, sume annos *aerae vel annos* (*om.*Mc) domini...". All versions presuppose that February has 28 or 29 days. The versions of Pz Mb Lx eliminate the reference

As appears from §4, the trigonometrical section (Oo32-122) is pretty well mirrored in Cb, even if re-translated or paraphrased. This need only mean that, once more, Cb depends on a text much like ours (see §9). However, most of the rules that do not involve tables have counterparts in Chapter III of Brahmagupta's *Khandakhadyaka*,[1] so probably these rules at least are authentic. For a doubtful passage that does concern a table, see the second example in §6.

The section on planets and on eclipses (Oo123-173) is likely to be pretty pure. Most of the text is found in Ibn Almuthanna; some of the extra passages contain repetitions and of trivial calculations, too uncontroversial for his type of commentary. I print this part of the text below.

The rules Oo174-212 present their own problems of authenticity. Goldstein's longer version of Ibn Almuthanna stops within Q87 (Oo180: excess of revolution), without indication as to how far it went originally. The Hugo version ends at Oo212 (time-of-night from stars), and one has to assume that this is where Ibn Almuthanna left off. I print the section of Oo covered by Hugo. The origin of the single pieces is dubious: thus, Oo181-205 (computation of kardagas) is out of place relatively to Ibn Almuthanna, and may incorporate some of his commentary (Q35); and Oo206-12 have much in common with Albattani. Perhaps all these rules are additional to Alkhwarizmi's canons, whether introduced by Ibn Almuthanna or by others before him.[2]

From Oo213 on, evidence from Ibn Almuthanna is absent, and other evidence seems insufficient:[3] Oo216-18 resemble the Maslama version, ch. 19 and 15, but Oo219-20 seem affiliated to Albattani, and they form an alternative to Oo123. I cannot tell when these rules were added.

§11. *Sample of Part A.*
I print a coherent sample of Part A (Oo123-212, f.81r-85r). Contents, parallels, and other witnesses can be found in §4, and references are listed in §3. For commentary the reader is generally referred to Goldstein 1967 and to

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to the Spanish Era; and Mb Lx add a table for Christian years, in the context. Perhaps the reference to Christian years is the secondary one.

1: As noted in Goldstein's commentary and by Mercier 1987, 106. Goldstein should be consulted for parallels to the rest of the text, which are numerous.

2: Cf. Goldstein p.242.

3: For instance, Abraham ibn Ezra (Millás 1947) has extensive quotations of Ibn Almuthanna, but none that are later than Q66. -- Oo213-215 (cf. Cb211-13) concern a table of projections of rays, incremented by 10°; this might be the same as the one rendered by Ibn Hibinta, cf. §8.

Pingree 1976, especially p.164-169; I cite Neugebauer on one or two particular points.

Text that has a counterpart in Ibn Almuthanna is italicised. I accept counterparts in either Goldstein or Millás, without notice except for large deviations, which are rare. If the text is in Goldstein's lemmas, the Q-number from Goldstein is cited; if not, a note is given. Extra text in the Ibn Almuthanna witnesses is noted in selection. A reference without a number or a note is meant to repeat the previous reference.

The text is printed on the basis of Oo. Thus, uncommented <insertions> and [deletions] are relative to Oo. Where there are other witnesses present (as is the case only for Oo126, 134, 174-80, 206-7) I keep to Oo where possible; notes are made where I depart from Oo, or where I accept the reading of Oo against all other witnesses.

The text of Oo is none too good. General problems are: *it()m*, which I have rendered as *item* except where *iterum* is necessary; *er()*, rendered as *erunt* in phrases like *et quod fuerit erunt minuta*; and *3*, which I have rendered as 2 or 3 according to the evidence. *Cito* for *scito* has been corrected tacitly. Other scribal vacillations, which I have mostly left alone, include: *dies*, masculine or feminine; *multiplica in* + accusative or ablative; *aspice* (usual before a question or a choice) once or twice for *accipe*; *medii eclipsis*, but *mediae eclipsis* twice in Oo172; *unam summitatem/-tum circini* in Oo150ff.

"§" stands for a big initial in Oo; this mostly starts a new paragraph.

(**Latitudes:** Moon (Oo123); five planets (Oo124-26). *Commentary,* on planets: Neugebauer 1962, 38-40.)

(**Oo123 Q56**) § Cum volueris scire *latitudinem lunae, minue Geuzahar[1] de luna aequata, et quod remanserit erit portio latitudinis. Pone eam sinum, et multiplica[a] eum[b] in IX, et* quod collectum fuerit *divide per V, et quod exierit erit latitudo lunae.* Et si[c] fuerit portio minus VI signis, erit latitudo septentrionalis, et si fuerit plus VI signis, erit meridiana, si deus voluerit, scito hoc.

(**Oo124 Q56a[2]**) § Cum volueris scire *latitudinem V planetarum,* quae est latitudo eorum[a] ab itinere solis, qui est circulus de annis, cum aequaveris

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1: Cf. the mere "Geuzahar" in Oo160 where the same procedure is applied, and contrast "corrected node", "recto Dracone", Q56. For the ways of reckoning the node, see note for Oo145.

2: Q56, p.92:11-15, "...he instructed us...". Hugo (Millás p.156) has this as a lemma, without ascription.

planetam, scito *portionem eius secundam,* accipiesque portionem cuiuscumque[b] planetae volueris; *pone eam sinum et [c]serva eum,* quia est sinus portionis. *Postea* aspice *aequationem* huius *portionis* et *pone* eam[d] *sinum,* et est sinus aequationis.[c] Deinde scito sinum <radicis> uniuscuiusque planetae, et est Saturni, id est sinus, minuta VII secunda XLIII, Iovis minuta XIIII secunda XXI, Martis minuta XXI secunda LV, Veneris minuta +CCC+, Mercurii XXVII minuta et secunda LI.[1] *Postea multiplica sinum radicis in sinu portionis, et divide* quod exierit *per sinum aequationis,* et quod exierit erit *radix latitudinis:* serva eam.

(Oo125 Q57) [a]*Et si fuerit numerus tuus Saturni* vel *Iovis aut Martis, minue Geuzahar* planetae *de loco eius aequato; si autem fuerit Veneris aut Mercurii, minue Geuzahar uniuscuiusque eorum de medio cursu eius;* et quod remanserit erit portio. Quae *si fuerit[b] minus VI[c] signis, erit latitudo septentrionalis,* et *si fuerit plus sex[d]* signis, *erit meridiana. Pone ipsam portionem sinum* et serva eum. Et *si fuerit numerus tuus Saturni, multiplica* eum[e] *in CXX minutis;[a]* et *si fuerit numerus tuus Iovis, multiplica* eum *in LX* minutis; et <*si*> fuerit *Martis,* multiplica eum *in nonaginta* minutis; et si fuerit *Veneris,* multiplica eum *in CXX* minutis; *et si Mercurii, in CL* minutis;[2] et *divide quod collectum fuerit per radicem latitudinis. Et quod exierit tibi* de minutis atque secundis, erit *latitudo planetae in parte qua invenisti eum,* si deus voluerit.

(**Velocities.** *Other witnesses:* Pz,99va; Mb,67va; Lx,155r. Cf. also Maslama, Suter c.29; Cb224.)

(Oo126 Q[3]) § Cum volueris scire *albuht[a] solis et lunae atque planetarum,* id est motus eorum aequales, in die qua volueris, aequa planetam super medium diem eiusdem diei. Quod[b] si fuerit tibi necesse scire albuht[c] futurae diei, adde super medium cursum, cum quo aequasti planetam, medium cursum unius diei et iterum aequa eum, et accipe superfluum quod fuerit inter utrumque, et hoc erit *motus* eius aequalis *ad unam diem.*

Et si fuerit tibi necesse scire hoc[d] ad praeteritum diem[e], minue de supradicto[f] medio cursu planetae medium cursum eius ad unam diem, et iterum

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1: The arcs of these sines (for a unit radius of 150, and reading 51;55 for Mars and 60 for Venus) are roughly half the maximum equations given in Q32 (which are 340', 652', 2431', 2831', 1290'). -- Cf. Ibn Almuthanna, Q56 p.92:22 "the sine of the radix for any planet is the sine of half its equation in the tables", cited by Kennedy / Ukashah p.94.

2: These are the values of *i'*, Neugebauer p.39.

3: Reference to this section in Q57, p.94:6-9: "...explicit in his tables ... You can derive the velocities according to his clear instructions", similarly in Hugo.

aequa eum, et accipe quod fuerit inter utrumque, et hoc erit motus eius aequalis in una die.

Si autem tibi fuerit[g] necesse scire hoc ad ipsam diem, adde super praedictum medium[h] cursum medium cursum eius ad dimidium unius diei, et aequa eum, et[j] accipe quod fuerit inter utrumque, et serva eum. Postea[k] minue de eodem medio cursu medium cursum eius ad medium unius diei, et iterum aequa eum, et accipe quod fuerit inter utrumque, et iunge eum illi quod servasti; et quod fuerit, erit buht[l] eius in eadem die, si deus voluerit.

(**Visibility:** Moon (Oo127-132); planets (Oo133).)

(**Oo127 Q61**) § Cum volueris scire *visionem lunae atque planetarum*, scito quod *non* operaberis[a] *visionem lunae nisi ad expletionem XXIX noctium[1]* transeuntium *de mense lunari, quod est <in nocte> tricesimi diei*, quia *in nocte tricesimi primi diei non erit dubium quin videatur*, et *in nocte vicesimi noni* diei *non suspicabitur videri: eritque opus super noctem tricesimi* diei.

(**Oo128 Q62**) Cumque volueris hoc scire, *constitue[a] solem et lunam ad occasum* solis *vicesimi noni diei*. Hoc est ut aspicias horas diei tui aequales, accipiesque <medium cursum eorum ad> dimidium earum, et addes eum super medium cursum vicesimi VIII diei; eritque hoc ad diem vicesimi noni diei[b] ad horam occasus solis. Aequa itaque solem et lunam et *Geuzahar[c]* ad ipsam horam, et scito *latitudinem lunae et partem eius. Postea adde super lunam tria signa*, eritque hoc *medium caelum lunae; <pone eum> sinum, et scito* [in qua parte sit declinatio illius gradus medii caeli] *partem eius. Post haec multiplica eum in latitudinem lunae, et divide quod collectum fuerit per 375, et quod exierit serva. Deinde aspice: si fuerit latitudo lunae et sinus medii caeli in una parte, minue quod exivit tibi de divisione de luna aequata; et si fuerint diversi[d], adde super lunam aequatam; et quod fuerit, erit luna aequata: serva eam.*

(**Oo129 Q63**) Post haec *fac latitudinem[2] eius*, et quod exierit tibi, *scito partem eius*. Deinde accipe *latitudinem regionis* et *pone* eam *sinum* et serva.[3] *Postea minue latitudinem regionis de nonaginta, et pone quod remanserit sinum, et erit sinus perfectionis latitudinis regionis.* <Postea *multiplica latitudinem lunae aequatae in sinu latitudinis regionis>,[4] et divide quod collectum fuerit per*

1: "diebus", Hugo; "nights", Goldstein's ms. before his correction.
2: "equated latitude", Q63, but "huius...latitudine...deprehensa" in Millás.
3: Preceding clause is only in Hugo.
4: Supplement from Q63, both versions.

sinum perfectionis latitudinis regionis, et quod exierit de gradibus atque minutis, serva. Deinde *aspice: si fuerit latitudo lunae aequatae in parte septentrionali, adde quod exivit tibi* de divisione *super lunam aequatam; et si fuerit in meridiana parte, minue eum de* ea; et *quod fuerit* post augmentum vel diminutionem, *erit locus lunae ad visionem.*

(Oo130 Q64) Qui si fuerit plus loco solis, accipe quod fuerit inter utrumque et verte eum per ascensiones nadir signi in quo fuerit. Si autem fuerint[a] in diversis signis, accipe quod remanserit soli in signo suo [ascensiones], et verte eum per ascensiones nadir signi solis; et accipe quod habuerit luna in signo suo [ascensiones], et verte eum per <ascensiones> nadir signi lunae, et collige utrumque. -- (Oo131 Q) Si autem volueris accipere quod est inter utrumque per tabulam, accipe quod fuerit in directo *nadir gradus solis de ascensionibus,* et serva eum. Accipe quoque quod fuerit in directo *nadir gradus lunae,* et serva eum. Postea *minue,* quod fuerit in directo nadir gradus solis, //Oo,81v// *de* eo quod fuerit in directo nadir gradus lunae, et *quod remanserit* erit *superfluum* quod est *inter utrumque.*[1]

Quod *si fuerit XII graduum vel plus, videbitur, et si fuerit minus, non videbitur.*

(Oo132 Q65[2]) Si fuerit quoque numerus tuus ad *visionem lunae in oriente,* mane, antequam transeat solem, idem erit opus, praeter quod aspicis quod exivit tibi de latitudine[a] lunae aequatae; multiplica in latitudine[b3] regionis divisa per perfectionem eius. Accipies scilicet quod exivit tibi de divisione, et si fuerit latitudo lunae septentrionalis, minues eum de luna aequata; si vero fuerit meridiana, addes eum super luna aequata. Postea accipies quod fuerit inter locum solis et locum lunae ad visionem, et vertes eum per *ascensiones signi in quo* oritur *luna;* et si[c] fuerit inter utrumque plus XII[d] gradibus, videbitur luna, et si fuerit minus, non videbitur.

(Oo133[4]) Opus quoque V planetarum idem est. Quod si fuerit inter Saturnum et solem plus XV gradibus, videbitur; <si plus 11 gradibus, Iupiter videbitur; si plus 17 gradibus, Mars;>[5] et si fuerit inter Venerem et solem plus VII gradibus, videbitur; et si fuerit inter Mercurium et solem plus XIII

1: From Oo130 up to here, only Hugo furnishes a parallel. It may pertain to either paragraph; I have noted it for Oo131, where the wording fits slightly better.

2: Reference to this section in Q65, p.102:13-14: "...he instructed you to...", not in Hugo.

3: Should be the sine of the latitude, cf. Oo129.

4: Not in Q. Same rule in another wording is in mss. Pz,99vb; Mb,67vb; Lx,155v. -- The same values (except for 9° in the case of Venus) are in the *Khandakhadyaka,* ch.6 Chatterjee.

5: Wording and values supplemented from mss. Pz Lx (Mb).

gradibus, videbitur. Et si fuerit in universis minus*a* hoc quod diximus, non videbitur*b*.

(**Eclipses:** Radii of luminaries and shadow. *Commentary:* Neugebauer p.58-59. *Other witnesses:* Pz,99vb; Mb, 67vb; Lx,155v. - Cf. Maslama, Suter c.30, 30a; "Investigantibus" c.250, 403.)

(**Oo134 Q66**) § Cum volueris scire quantitatem *circuli solis, accipe buth*a *soli*s et pone eum totum *secunda,* et quod fuerit, *multiplica eum*b *in XI et divide per XX, et quod exierit* erunt secunda; pone ea minuta, et haec *erit quantitas circuli solis.*

§ *Cum volueris* scire *quantitatem circuli lunae,* accipe *buth lunae et fac* eum totum *secunda; et multiplica eum in X et divide per CCXLVII, et quod exierit erunt secunda; pone ea minuta, et* quod fuerit *erit quantitas circuli lunae.*

§ *Cum volueris* scire *quantitatem* circuli *Geuzahar, accipe buth solis* et fac eum secunda; et similiter fac buth *lunae secunda; et multiplica buth solis in XXV et buth lunae in VIII.* Post haec *minue minorem*c *de maiori, et quod remanserit pone minuta; et* quod fuerit, *erit quantitas circuli*d *Geuzaar,* si deus voluerit*e*.

(Eclipses: Mean syzygy (Oo135); true syzygy (Oo136-40).)

(**Oo135 Q58**) § Cum volueris scire coniunctionem et impletionem, *aequa solem et lunam* ad medium diem *diei vicesimi noni* mensis lunaris, *si volueris coniunctionem; si volueris impletionem, aequa ad diem quartum decimum* eiusdem *mensis* lunaris.

(**Oo136 Q59**) Postea *scito buth solis et buth lunae,*[1] *et minue buth*a *solis de* buth*b lunae, et quod remanserit erit albuth aequatus.* (**Oo137 Q**²) Deinde *scito horas diei tui,* horas quoque medii diei tui, *et horas noctis tuae.* Si autem fuerit numerus tuus ad impletionem, adde super lunam VI signa. Post haec *accipe superfluum* quod fuerit *inter* solem et lunam, et *erit longitudo;* serva eam. Si autem fuerit luna plus gradibus quam sol, erit longitudo lunae, et si fuerit sol plus gradibus quam luna, erit longitudo solis. Et si fuerit numerus ad coniunctionem, accipe differentiam*c* quae fuerit inter utrumque, et non addas super lunam quicquam; et scito cuius sit longitudo. Postea fac *longitudinem* totam secunda et *multiplica* eam in XXIIII, et *divide* quod collectum fuerit *per*

1: So far, cf. Q58 p.94:20-21 "...he instructed you...".

2: Traces in Q58 p.94:20 "...he instructed you..."; Q59 p.95:7-10 "(Al-Khw.) can find..."; Q59 p.95:17-18 "...he instructed you...".

buth aequatum, postquam reddideris[a] eum secunda, et quod exierit erunt horae; quodque remanserit multiplica in LX et divide per buth aequatum, et quod exierit erunt minuta [pars] unius horae. Quodque exierit ex horis et minutis, erunt horae longitudinis: serva eas.

(Oo138 Q59a[1]) Post haec aspice: *si fuerit longitudo solis, adde horas longitudinis super medium diem* diei tui cui numerasti. Hoc est ut aspicias: si fuerint horae longitudinis minus horis <medii diei, hoc erit quod transivit de horis> eiusdem diei [et ipsa] in qua fuerit coniunctio vel impletio. Et si fuerint horae longitudinis plus horis medii diei, minue de eis[a] horas medii diei, et quod remanserit, ipsum est quod transivit de horis noctis. Si autem fuerit plus horis noctis, minue de eo horas noctis, et quod remanserit, ipsum est quod transivit ex die <de> horis, ex die scilicet qui est post ipsum diem cui numerasti. - (Oo139 Q) Et *si fuerit longitudo lunae, minue horas longitudinis* <**>[2] de XXIIII horis, et serva quod remanserit ex horis atque minutis. Postea aspice: si fuerit minus horis medii diei, [adde super eas horas medii diei, et quod fuerit][3] erit quod transivit de die scilicet quae est ante diem cui numerasti coniunctionem vel praeventionem. Et si fueri<n>t horae[a] plus horis medii diei, minue de eis horas medii diei, et quod remanserit[b] erit quod transivit de nocte, de nocte scilicet quae est ante noctem tuam, in qua numerasti coniunctionem vel impletionem, nisi sit illud quod remansit plus horis noctis. Et si fuerit plus, minue ex eo horas noctis, et quod remanserit erit quod transivit de die tua cui numerasti.

(Oo140 Q60) Et *si volueris <scire> locum solis et lunae ad horam coniunctionis vel impletionis, accipe longitudinem, et multiplica eam in buth solis, et divide per buth aequatum,* et *quod exierit de minutis atque secundis serva.* Postea aspice: *si fuerit longitudo solis, adde quod exivit* tibi *super solem aequatum; et si fuerit longitudo lunae, minue eum* de loco solis aequati; et quod remanserit post diminutionem vel augmentum, erit locus solis ad horam coniunctionis vel impletionis.[4] *Postea accipe buth lunae, et multiplica eum in*

1: Q59, p.95:22-25 "He said...". This is a lemma in Millás p.159.

2: "subtract ... from the hour of noon", Q59, p.95:25. Perhaps, cf. Oo138, *"minue horas longitudinis <de medio die* diei tui cui numerasti. Hoc est ut minuas horas longitudinis> de XXIIII horis...".* In any case the result will be the hours elapsed after noon of the preceding day.

3: This addition is wrong. One might read "eas super", and take the last "horas medii diei" to mean "noon (of the preceding day)" instead of the usual "half the day-length"; but this would make the passage redundant.

4: "Postea aspice...": this passage, and the next one on addition/ subtraction, are found as one common passage in both versions of Q, near the end of the paragraph. -- The clause on "longitudo lunae" is only in Hugo.

longitudinem, et divide quemadmodum divisisti ad solem, *et quod exierit de gradibus atque minutis* et secundis, *serva.* Tunc si addidisti[a] super solem[b], adde quod exivit tibi de numero lunae super lunam[c]; et si minuisti de sole, minue quod exivit tibi de numero lunae de luna.

Tunc *si conveniunt* utraque *in uno minuto,* iam invenisti; *sin autem, erravisti; reitera numerum tuum,* si deus voluerit.

(**Lunar eclipses.** -- Q67a-e, and part of Q68, are lost in a lacuna in Goldstein's text. They are lemmas in Millás p.171-73.)

(**Oo141 Q67**) § Cum volueris scire *eclipsim lunae, aspice impletionem,* quae fuerit *cum sol fuerit prope caput vel caudam* secundum quantitatem *XIII[1] graduum vel infra;* (**Oo Q67a**) et *scito* utrum sit hora *impletionis in nocte, vel post ortum solis per quantitatem unius horae* vel minus, *aut ante occasum per quantitatem unius horae vel minus. Scito* igitur *horam impletionis, et constitue Geuzahar[a] eiusdem horae; et numera latitudinem lunae, ac scito partem //Oo,82r// eius,* utrum sit in[b] septentrione vel in meridie. *Scito quoque quod[c] horae impletionis sint* horae *medii[d] eclipsis, si fuerit eclipsis.* (**Oo Q67b**) Et *scito* quantitatem circuli lunae et quantitatem circuli *Geuzahar; postea iunge* utrumque *et proice medium eius quod collectum fuerit;* et quod fuerit *erit dimidium utriusque quantitatis:* serva eum.

(**Oo142 Q**) Post haec aspice: *si fuerit latitudo lunae plus dimidio utriusque quantitatis, non obscurabitur* luna; et *si fuerit minus* dimidio *utriusque* quantitatis, *obscurabitur.* (**Oo Q67c**) [2]*Minue igitur* eam *de dimidio utriusque* quantitatis, et *quod remanserit* serva. Quod *si fuerit simile* quantitati *circuli lunae,* luna *obscurabitur tota, et non* erit ei *mora[a];* (**Oo Q67d**) et *si fuerit plus* quantitate circuli lunae[3], *obscurabitur tota,* et [non] erit ei *mora[b];* (**Oo Q67e**) *si autem fuerit minus* quantitate circuli lunae, *obscurabitur pars* eius. Et *cum volueris scire quantum obscurabitur* de ea, *multiplica* ipsum *residuum[4] in XII* et *divide per quantitatem circuli lunae,* et quod exierit *erunt puncti; quod remanserit multiplica in LX et divide* quemadmodum divisisti[c], et *quod exierit erunt minuta* unius *puncti;* et hoc *erit quod obscurabitur de luna.*

(**Oo143 Q68**) Et si volueris *scire horas casus* vel *morae,* accipe *dimidium quantitatis circuli Geuzahar et pone* eum *in duobus locis.* Post haec accipe

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1: 13° in both versions of Ibn Almuthanna, "XII" in Oo.

2: In Q67c (Millás p.271) the chapter starts "Cum ergo de eclipsi nulla sit ambiguitas...".

3: q.c.l.: "utriusque mensure medio" Q67d (p.172 Mill.), wrongly.

4: ipsum r.: "utriusque medii circuli unde prius portio latitudinis dempta est reliquum" Q67e (Mill. p.172), merely a clarification.

latitudinem lunae et *adde* eam[a] *super unum* locorum *et minue eam de altero.*
Deinde multiplica augmentatum [1]*in diminuto, et accipe radicem eius quod*
collectum fuerit, et adde eam super dimidium quantitatis circuli lunae, et *quod*
fuerit erunt minuta. [Et ipse est, diminuto[b] ex eo motu solis sicut dictum est
superius, buth aequatus.][2] **(Oo144 Q69)** *Pone* eum *secunda,* et *fac* similiter
buth lunae secunda, et *multiplica unum* eorum *in alium,*[3] *et divide per*
portionem motus, id est motus lunae *aequatus*[a] [sine diminutione motus solis,][4]
postquam *feceris* portionem motus *secunda; et quod exierit erunt secunda; fac*
ea minuta. Postea *pone lunam aequatam ad medium eclipsis in duobus locis,*
et *adde* eum[b] *super unum locorum et minue de alio; eritque*[c] *diminutus locus*
lunae ad initium eclipsis, et augmentatus locus ad perfectionem detectionis[d].

(**Oo145 Q**[5]) Postea accipe minuta casus et multiplica ea in *motu Geuzahar*
ad unum diem, et divide per portionem motus, et quod exierit serva. Deinde
pone Geuzahar ad medium eclipsis in duobus locis, et minue eum de uno
locorum, et adde eum super alium; eritque diminutus locus Geuzahar ad
perfectionem detectionis, et augmentatus locus eius ad initium eclipsis.[6] Post
haec *fac latitudinem lunae* per locum lunae et Geuzahar *ad initium eclipsis, et*
scito partem eius de septentrione vel meridie; *serva eam*[a]. *Item fac latitudinem*
eius ad perfectionem detectionis, et scito partem eius.

(**Oo146 Q70**) Deinde *pone dimidium quantitatis circuli Geuzahar in duobus*
locis, et adde super unum eorum latitudinem lunae ad initium eclipsis, et minue
eam de alio, et *multiplica* augmentatum[a] in diminuto, *et serva eum.* Post haec
accipe superfluum quod fuerit *inter latitudinem lunae ad medium eclipsis et*
latitudinem eius ad initium eclipsis, et multiplica eum in semetipso, et adde eum
super illud quod servasti, et accipe radicem eius quod collectum fuerit, et *pone*
eam in duobus locis. Deinde *adde* [eum] *super unum* locorum *dimidium*
quantitatis circuli lunae[7], *et minue eum ab alio, et serva* utrumque; *eritque*

1: End of lacuna in Goldstein. For the first part of this paragraph cf., however, Goldstein
p.112:31-113:5, "...he instructed you...".

2: Gloss meant for "buth lunae" or "portionem motus" in Oo144, cf. below.

3: "et fac similter ..." present only in Hugo.

4: To get the time elapsed, one should divide by the velocity difference ("portio motus" or
"motus aequatus (-lis Oo)" here; "albuth aequatus" in Oo136/Q59; "albuht rectum" in Hugo at
both places). To get the distance travelled by the moon during this time, one should then
multiply by the raw lunar velocity ("buth lunae"). The glosses here and in Oo143, both in
context, are placed so as to indicate the opposite.

5: Cf. Q69, p.114:8-9.14-17, "...he said..." (twice).

6: "diminutus / augmentatus": thus the place of the node is counted in the negative direction,
as in Oo162, but contrary to Oo123 and Oo160. Cf. Neugebauer p.33 n.2.

7: "lunae" Oo, rightly; "draconis" Millás, "node" Goldstein's ms. before his correction.

augmentatus minuta casus[1] aequata ad initium eclipsis, et diminutus minuta morae[2] ad initium eclipsis. -- (**Oo147 Q**) *Deinde multiplica unumquemque eorum in XXIIII, et divide per portionem motus,* et *quod exierit erunt horae;* quodque remanserit multiplica in LX et divide quemadmodum divisisti, et quod exierit erunt minuta unius horae. Et quod exierit de *augmentato[a] erunt horae casus ad initium eclipsis,* et quod exierit de *diminuto[b] erunt horae morae* ad initium eclipsis, si fuerit mora; serva illud. Si autem non fuerit mora, nihil tibi exivit.

(**Oo148 Q[3]**) Post haec[a] *accipe latitudinem lunae ad perfectionem[b] detectionis,* et minue eam de dimidio quantitatis circuli Geuzahar, et adde eam super dimidium quantitatis circuli Geuzahar, et multiplica augmentatum in diminuto, ac serva eum. Post <haec> accipe[c] superfluum quod fuerit inter latitudinem lunae ad medium eclipsis et latitudinem eius ad perfectionem detectionis, et multiplica eum in semetipso, et adde eum super id quod servasti. Deinde accipe radicem eius quod collectum fuerit, et pone eam[d] in duobus locis, et adde super unum eorum dimidium quantitatis circuli lunae, et minue eum de alio; eritque augmentatus[e] minuta casus aequata ad perfectionem detectionis, et diminutus minuta morae ad perfectionem detectionis. -- Post haec et multiplica unumquemque eorum in XXIIII, et divide per portionem motus; et quod exierit erunt horae, et quod remanserit <**>[4] erunt minuta; quodque exierit <de> augmentato erunt *horae casus <ad> perfectionem detectionis,* et quod exierit de diminuto[f], erunt horae morae ad perfectionem detectionis; serva hoc totum.

(**Oo149[5]**) Postea pone horas medii eclipsis in duobus locis, et minue de uno locorum horas casus ad initium eclipsis, et adde super alium horas casus ad perfectionem detectionis; eritque diminutus ex eis horae initii inceptionis, et augmentatus horae perfectionis recessionis[a]. Item pone horas medii eclipsis in duobus locis, et minue de uno eorum horas morae ad initium eclipsis, et adde super alium horas morae ad perfectionem detectionis; eritque diminutus ex eis horae perfectionis eclipsis, quod est initium morae[b], et augmentatus horae perfectionis morae, quod est initium detectionis.

Haec sunt V tempora, quorum primum est initium eclipsis, secundum perfectio eclipsis et initium morae, tertium medium eclipsis, quartum perfectio morae et initium detectionis, V'tum finis detectionis.

1: "minutes of half-duration", Goldst.
2: "minutes of the first half of totality", Goldst.
3: Cf. Q70, p.116:16-19 "precepit" Hugo, no ascription in Goldstein.
4: To be supplemented from Oo147, or else to be read "pone minuta", cf. Oo174.
5: Not in Q.

(Lunar eclipses: Figure (Oo150-153); colours (Oo154). -- Ibn Almuthanna shows no lemmas corresponding to these sections, but some of the wording can be recognized in his exposition of Q70, cf. the notes. There are ascriptions to Alkhwarizmi as concerns Oo150 and Oo154. -- Eclipse figure, cf. Albattani c.43 and Ca156. For illustration one may also use Goldstein's figure, p.117, or my diagram for Cb208a.)

(**Oo150 Q^1**) § Cum volueris figurare vel depingere eclipsim, fac *lineam* aequalem et *divide* eam *aequali divisione* secundum quantitatem quam volueris, tamen^a ut sit numerus eius similis quantitati circuli Geuzahar vel plus. Et *accipe* //Oo,82v// *ex* ea *secundum* quantitatem *numeri minutorum* circuli *Geuzahar*, per *circinum^b* vel per *lineam*, et pone unam^c summitatem circini^d in loco aequali, et *fac circulum, quem vocabis circulum maiorem.* Deinde *accipe* de linea divisa secundum quantitatem *dimidii quantitatis circuli Geuzahar* per circinum^e, et pone unam summitatem eius in cuspide circuli maioris, et *fac circulum* in medio circuli maioris, qui erit *circulus Geuzahar.* Et *divide utrosque circulos per* duas *lineas* abscidentes se invicem *super cuspidem* utrorumque circulorum, ut dividas eos in IIII'or partes. Post haec pone super summitatem uniuscuiusque lineae partem eius; eritque *oriens* in directo *occidentis,* et *septentrio* in directo *meridiei.*

(**Oo151 Q^2**) Item *accipe de* praedicta *linea divisa secundum quantitatem latitudinis lunae ad medium eclipsis, et pone unam summitatem circini* super cuspidem utrorumque^a circulorum, *et aliam* quo pervenerit ex meridie vel septentrione, in parte scilicet *latitudinis,* et signabis locum. Postea *accipe dimidium quantitatis circuli lunae,* et pone unam summitatem^b circini super locum signatum, et *fac circulum,* qui erit *circulus lunae* ad medium eclipsis. Tunc si pars lunae obscurabitur^c, quicquid intraverit *ex circulo lunae in circulum Geuzahar, ipsum est quod obscurabitur* de luna. Et *si tota* debuerit *obscurari* et non fuerit ei mora, *intrabit circulus lunae totus in circulum Geuzahar,^{3}* et continget margo illius marginem alterius, et nihil remanebit ex eo superfluum. Si autem fuerit ei mora, intrabit circulus lunae totus in circulum Geuzahar, et remanebit ex circulo Geuzahar super utrumque latus lunae aliquid superfluum, et secundum hoc erit luna.

(**Oo152 Q^4**) Post haec *accipe latitudinem lunae ad initium eclipsis, et pone unam summitatem circini^a super cuspidem utrorumque circulorum, et aliam* quo

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1: Cf. Q70, p.117,1ff.: "...(al-Khwarizmi) instructed you to..."; "...as he directed...", etc. -- Part of the parallels are from Hugo.

2: Cf. Q70, p.118:4ff.; no ascription in either version.

3: "Et si tota..." only in Hugo, Millás p.178.

4: Cf. Q70, p.118:13-23, no ascription.

pervenerit ex septentrione vel meridie *super partem latitudinis,* et signabis locum. Postea *extrahe lineam rectam ab* eodem loco signato, ducens eam *ad circulum maiorem* versus occidentem, donec contingat circulum maiorem; deinde quadra +eum+[1] versus diametrum circuli maioris. -- Et iterum *accipe latitudinem lunae ad perfectionem detectionis, et pone unam summitatum circini* super cuspidem circuli, *et aliam* quo pervenerit ex meridie vel ex septentrione, super partem scilicet latitudinis, <et> signabis locum. Et *extrahes* ab eodem signo *lineam* rectam *ad circulum maiorem versus orientem,* donec contingat praedictum *circulum,* et quadrabis +eum+ super diametrum circuli maioris.

(Oo153 Q[2]) *Post haec accipe minuta casus aequata ad initium eclipsis* per *circinum*[a], *et pone unam summitatum eius* super cuspidem circuli lunae ad medium eclipsis, *et aliam* quo pervenerit de linea quam extendisti in terminum[b] latitudinis lunae ad initium eclipsis versus occidentem, et signabis locum quo pervenerit. Deinde accipe *minuta casus aequata ad perfectionem detectionis* <**>[3] versus orientem, et signa *locum quo pervenerit.* Deinde *extende lineam* ab uno horum signorum ad aliud, quae *abscidat punctum lunae circuli ad medium eclipsis;* super quam *lineam vadit* punctus *lunae ab initio inceptionis eclipsis usque in perfectionem detectionis.*

Postea accipe dimidium quantitatis circuli lunae per circinum, *et pone unam summitatum eius* super unum signorum, et *fac circulum* qui[c] *contingat circulum Geuzahar;* item pone circinum super aliud signum, et fac circulum *contingentem circulum Geuzahar.* Eritque *circulus,* qui[d] fuerit in parte occidentis, *circulus lunae ad initium eclipsis,* et ille, qui fuerit in parte orientis, *circulus lunae ad perfectionem detectionis.*

(Oo154 Q[4]) § Cum volueris scire *colores eclipsis,* aspice latitudinem lunae. Si fuerit ab uno minuto in X, erit eclipsis nigerrima; et si fuerit usque in XX minuta, erit nigra habens in se viriditatem; et si fuerit in XXX, erit nigra cum rubedine; et si fuerit in XL, erit nigra cum pallore; et si fuerit in L, erit grisii coloris; et si excesserit L, erit grisia cum albedine.

Est quoque ei alius modus qui iungitur modo primo, donec scrutemur scientiam coloris eius. Hic est ut aspicias: si fuerit locus lunae plus auge eius

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1: One expects "draw a line (=lineam) ... *at right angles* to the diameter" (cf. Q70, p.118,16-17), but then the "deinde" is awkward. A similar expression is at the end of this paragraph; I have not seen it elsewhere.

2: Cf. Q70, p.118:26-119:16.

3: <per circinum et pone ... ad initium eclipsis>, cf. the preceding formula.

4: Reference in Q70, p.119:17 "The colors ... which he mentioned". This paragraph is a common gloss in the manuscripts of Cb.

per sex signa, erit nigerrima; et si fuerit plus auge eius per V^a signa vel per VII, erit nigra cum viriditate; et si fuerit plus auge eius per IIII^b vel per VIII, erit nigra cum rubedine; et si fuerit plus auge eius per III signa vel per novem, erit nigra cum pallore; et si fuerit plus auge eius per II'o signa vel per X, erit grisia; si autem fuerit plus auge eius per <unum> signum vel per XI, erit grisia cum albedine, si deus voluerit.

(**Solar eclipses:** General (Oo155); parallax in longitude (Oo156-59).)

(**Oo155 Q71**) § Cum volueris scire *eclipsim solis, aspice*[a] *coniunctionem* quae fuerit *in die, cum fuerit sol prope caput vel caudam,* et numera coniunctionem, et *scito* in qua *hora diei* sit[b]; scito quoque *et horas medii diei tui.*

(**Oo156 Q72**) [1]*Postea accipe longitudinem* quae fuerit *inter horam coniunctionis et medium diem de horis aequalibus, sive fuerit coniunctio ante medium diem vel post ipsum,* et *pone unamquamque horam XV gradus* et *omnia IIII minuta* unius horae *unum gradum*[a]; *et quod non perfecerit*[b] *IIII minuta, accipe portionem eius de uno gradu.* Post haec *pone, quod collectum tibi fuerit de gradibus atque minutis,*[2] *sinum,* et *multiplica quod exierit de sinu in IIII, ac divide per trescentos septuaginta quinque,* et *quod exierit erunt horae;* quodque remanserit multiplica in LX et divide quemadmodum divisisti, et quod exierit erunt minuta; et *quod fuerit* ex *horis atque minutis, serva,* quia sunt *horae visionis primae.* Et *si fuerit coniunctio ante medium diem, minue eas de hora coniunctionis; si vero fuerit post medium diem, adde eas super horas coniunctionis;* et *quod fuerit* erunt *horae coniunctionis aequatae: serva eas.*

(**Oo157 Q73**) Item *accipe longitudinem quae fuerit inter horas coniunctionis aequatas et* horas *medii diei, et operare* cum eis[3] *quemadmodum prius* operatus es[a]; et *quod exierit de horis atque minutis, erunt horae visionis secundae: serva eas.* Postea aspice: *si fuerit coniunctio ante medium diem, minue eas de horis coniunctionis, et si fuerit post medium diem, adde eas* super horas coniunctionis; *et quod fuerit* erunt *horae coniunctionis*[b] aequatae bis.

1: Goldstein prefixes "know the hours of the conjunction", not in Hugo, perhaps a resumption of Oo155.

2: "et quod non...": mainly absent from Goldstein. Here and elsewhere in Oo156-57, Hugo is the only one to take account of fractions.

3: *sc.* horis longitudinis *vel sim.*; or requiring "longitudines quae fuerint", as in Oo158, but unlike Oo156. One might opt for the plural everywhere, this being the scribe's final impression. Oo also vacillates between "hora / horae coniunctionis"; this has not been corrected either.

(Oo158 Q*1*) Item accipe longitudines quae fuerint inter ipsas horas et horas medii diei, et operare cum eis quemadmodum operatus es prius; et quod exierit de horis atque minutis, erunt horae visionis tertiae. Quae*a si fuerint aequales* horis visionis *secundae, iam*[b] *verificatae* sunt tibi horae aequatae[c] bis. *Si vero non fuerint aequales,* <minue eas> de horis[d] coniunctionis primae, si fuerit coniunctio ante medium diem, vel adde eas super eas, si fuerit coniunctio post medium diem; et quod fuerit erunt horae aequatae[e] tribus vicibus.

Operare cum eis quemadmodum operatus es cum horis coniunctionis primae; et quod exierit tibi de horis atque //Oo,83r// minutis, erunt horae visionis quartae; serva eas. Quae si[f] aequales fuerint horis +utriusque+*2* visionis, iam perfecte erunt horae coniunctionis[g] aequatae. Si vero non fuerint aequales, *operare hoc sexties, donec aequentur.* Si autem non fuerint aequatae in opere quinto vel VI'to, iam errasti; reitera numerum[h] tuum, donec aequentur. Cumque aequatae fuerint, quicquid exierit tibi de horis aequalibus erunt *horae medii eclipsis:* serva eas.

(Oo159 Q74) Post haec *accipe horas coniunctionis I'ae, et multiplica eas in*[a] *buth solis, et divide* quod collectum fuerit *per XXIIII'or,* et *quod exierit* erunt minuta, quodque remanserit pone secunda. Deinde *minue* haec *minuta atque secunda*[b] <de> *aequatione*3 *solis ad horas coniunctionis,* et *quod remanserit erit locus solis ad ortum eius* eadem die.

(Solar eclipses: Parallax in latitude, etc. (Oo160-63); digits of immersion (Oo164-165). -- *Other witnesses:* Another version of Oo160-165 is in Oo316-320, 89r-v; Mc,44r-v; "Investigantibus" c.441-5. This has not been collated.)

(Oo160 Q75) <Cum volueris scire latitudinem visionis quae est inter solem et lunam hora coniunctionis, quae nominatur diversitas aspectus in latitudine, *constitue ascendens ad horam coniunctionis.*>*4 Deinde minue de ascendente*[a] *nonaginta gradus,* et *quod remanserit erit portio ascendentis;* accipe declinationem eius, et scito partem eius, et quod exierit tibi de declinatione, *serva,* et *voca eum declinationem*[b] *portionis ascendentis. Post haec accipe portionem ascendentis, et minue de ea Geuzahar ad horam coniunctionis,* et *quod remanserit pone sinum;* quodque exierit de sinu *multiplica in IX et divide per*

1: Cf. Q73, p.125:15-25 "...he instructed you...".

2: Should be "tertiae".

3: "corrected position" Goldstein; "loco solis" Hugo.

4: Supplemented, by way of example, from the alternative version (see heading). The last clause, at least, is present in Q75, both versions.

V, et *quod exierit serva, et scito^c partem eius^1*, et voca eum *latitudinem portionis ascendentis.*

(**Oo161 Q76**) Post haec aspice *latitudinem portionis ascendentis et declinationem* eius: *si fuerint^a* utraeque *in unam partem, iunge eas, et si fuerint diversae, minue minorem de maiore, et quod fuerit serva, et* scito *partem eius,* et *est* semper *in parte maioris^b*. *Si* autem *fuerit in parte meridiei, adde eum super latitudinem climatis,* et *si fuerit in septentrione, minue eum^c de latitudine* climatis, *et quod remanserit serva,* quia *est latitudo aequata, et est semper meridiana. Pone* itaque *eam sinum,* et *multiplica* quod exierit tibi de sinu *in XIII et divide per XL;* et *quod exierit* de minutis atque secundis *erit latitudo* quae est *inter solem et lunam ad visionem,* et *est semper meridiana.*

(**Oo162 Q77**) Deinde *fac latitudinem lunae ad horas mediae eclipsis;* et *oportet te scire^a locum lunae* et locum *Geuzahar ad ipsas horas.*

Cuius scientia est ut *accipias* quod est *inter horas mediae eclipsis et horas coniunctionis I'ae de horis atque minutis, et multiplices eum in buth lunae, et divides quod collectum fuerit per XXIIII, et minues quod collectum fuerit* de minutis atque secundis *ex loco lunae ad horam coniunctionis, si fuerit coniunctio ante medium diem, et addes eum super locum lunae, si fuerit post medium diem; erit*que hic *locus lunae,* si deus voluerit, *ad horas mediae eclipsis.* Et *operaberis^b cum Geuzahar similiter; sed^c addes quod exierit* tibi *super Geuzahar, si fuerit coniunctio ante medium diem, et si fuerit^d post medium diem, minues eum;* et quod *exierit* erit *locus Geuzahar ad* horam *mediae eclipsis. Operare* quoque et *latitudinem lunae per locum lunae et* locum *Geuzahar,* et scito *partem eius.*

Post haec aspice: si fuerit latitudo lunae et latitudo^e <visionis>^2 quae^f est *inter lunam et solem in una parte, iunge utrasque, et si fuerint diversae, minue minorem de maiori, et quod remanserit serva, et scito partem eius,* quia *est latitudo lunae ordinata.*

(**Oo163 Q77a^3**) Postea accipe quantitatem *circuli solis et* quantitatem circuli *lunae et iunge* utrasque^a, et *accipe dimidium eius quod collectum fuerit,* et serva, et *voca eum dimidium utriusque* quantitatis. Deinde aspice: *si fuerit dimidium utriusque* quantitatis *plus latitudine^b lunae ordinata, obscurabitur sol,* et si dimidium utriusque quantitatis *fuerit minus* latitudine lunae ordinata, *non^c* obscurabitur.

1: also "qua *mundi sit plaga* agnoscas", Mill.; contrast "know its *derivation*" Goldst. -- Still probably "*scito* (serva Oo) partem eius".

2: "apparent latitude" Goldst.; "ad videndum distantiam" Mill.

3: Lemma in Millás p.189; absent from Goldstein's text, which has a lacuna after p.130:23.

(Oo164 Q77b[1]) *Si* autem noveris quod *obscuretur, minue latitudinem lunae ordinatam de dimidio utriusque quantitatis* et serva *quod remanserit;* quod *si fuerit plus quantitate circuli solis vel simile* eius, *obscurabitur sol totus;* si vero fuerit *minus* quantitate circuli solis, *obscurabitur pars eius.*

(Oo165 Q78) Tunc *multiplica hoc[2] in XII et divide per quantitatem circuli solis,* et *quod exierit erunt puncti;* et quod remanserit multiplica in LX et divide quemadmodum divisisti, et quod exierit tibi erunt minuta unius puncti; quodque collectum fuerit ex punctis atque minutis, erunt puncti eclipsis *inaequati.*

(Solar eclipses: Area digits (Oo166-71); duration etc. (Oo172). -- Q81a-c are lemmas in Millás p.193-95. Lemmas and commentary are not in Goldstein's text.

The areas calculated are: (Q81) sector of sun, "divisum"; (Q81a) segment of sun, "dimensio arcus solis"; (Q81b) sector of moon, "dimensio" (="mensura" in Q); (Q81c) segment of moon, "dimensio arcus lunae".)

(Oo166 Q79) *Si* autem *volueris aequare punctos* eclipsis, *accipe quantitatem circuli lunae, et multiplica eam in XII, et divide per quantitatem circuli solis,* et *quod exierit erit quantitas circuli lunae aequata; serva eam. Deinde adde super eam XII, et quod fuerit, minue de eo punctos eclipsis duplatos,* et *quod remanserit erit pars; serva eam.*

(Oo167 Q80) Postea minue punctos eclipsis de XII, et quod remanserit multiplica in punctos eclipsis, et quod fuerit divide per partem, et quod exierit erit portio circuli <lunae. Et minue portionem circuli lunae de punctis eclipsis, et quod remanserit erit portio circuli> solis.[3]

Postea accipe *portionem circuli solis,* <et *minue* eam *de 12,* et *quod remanserit multiplica in portionem circuli solis,* > et *accipe radicem eius quod exierit, et serva, et est sinus arcus.*

(Oo168 Q81) *Multiplica* itaque *eum sinum in XXV,* et *quod collectum fuerit fac arcum, et multiplica* quod exierit de *arcu in XXII'bus, et divide per triginta et V,* et *quod exierit serva,* et est *divisum.* **(Oo169 Q81a)** *Postea multiplica radicem quam servasti, quae est sinus* arcus, *in superfluitatem* qua[a] *superat VI portionem circuli solis,* et *proice quod collectum fuerit de diviso[b],* et quod remanserit *erit dimensio[c] arcus solis;* serva eam.

1: Q77b (=p.132:11-15) and Q78 are parts of the same lemma in Millás p.190.

2: "hoc": "reliquum utriusque medii post latitudinem videlicet detractam", Hugo, clarification.

3: "portio circuli solis" = "sagitta of the circle of the sun", Goldst., "alieb solaris circuli", Hugo. -- This period (with my supplement, which is e.g.) renders Goldstein p.239 equ.(7), where the last term should read (KZ+KT)/KZ. It is absent from Q, both versions.

(**Oo Q81b**) Post haec accipe*[d] radicem quam servasti, quae est sinus arcus,* et *multiplica* eam *in 300,* et *divide per circulum lunae aequatum,* et *quod exierit pone arcum,* et *serva. Deinde multiplica circulum lunae aequatum in semetipso,* et *multiplica quod collectum fuerit in XI,* et *quod fuerit multiplica* iterum *in arcu quem servasti,* et *divide quod collectum fuerit per 2520[e],* et *quod exierit erit dimensio[f]; serva eam.* (**Oo170 Q81c**) *Postea[a] minue portionem <circuli> lunae de dimidio circuli* lunae *aequati,* et *multiplica quod remanserit in radice quam servasti,* et *minue quod collectum fuerit de dimensione quam servasti,* et *quod remanserit* erit dimensio arcus lunae.

Iunge eum *cum dimensione arcus solis,* et *multiplica quod collectum fuerit in VII,* et *divide[b] per LXVI,* et *quod exierit erunt puncti eclipsis aequati.[1]*

(**Oo171 Q82**) Et *si volueris aequare hos punctos de tabula, accipe portionem circuli solis* et *intra cum eo in tabulam[a] magnitudinis[2],* et *accipe* quod *in directo eius* fuerit de *punctis atque minutis,* et serva eum, quia *est aequatio prima. Post haec accipe portionem circuli lunae,* et *multiplica eam in XII,* et *divide super quantitatem circuli lunae aequatae,* et *quod exierit, intra cum eo* in praedictam *tabulam,* et *accipe quod in directo eius fuerit,* et haec *erit aequatio secunda. Deinde multiplica quantitatem circuli lunae in semetipsam,* et *divide* quod collectum fuerit *per CXLIIII,* et *multiplica quod exierit in aequatione secunda,* et *adde quod collectum fuerit super aequationem primam,* et *quod fuerit* erunt *puncti eclipsis aequati.*

(**Oo172 Q83**) § *Cum volueris* quoque *scire horas eclipsis, multiplica dimidium utriusque quantitatis in semetipso* //Oo,83v// *et serva eum.* Et *multiplica latitudinem lunae ordinatam in semetipsam,* et *minue* eam *de* multiplicatione dimidii utriusque quantitatis in semetipso, et *accipe radicem eius quod remanserit; et multiplica* eam *in XXIIII,* et *divide per portionem[a] motus,* et quod *exierit* erunt *horae; quodque remanserit multiplica in LX* et *divide quemadmodum divisisti,* et quod exierit *<erunt minuta. Et quod exierit> de horis atque minutis erunt horae casus;* serva eas. Deinde *minue* horas casus *de horis mediae eclipsis,* et *quod remanserit erunt horae initii* inceptionis *eclipsis. Adde* quoque *eas super horas mediae eclipsis,* et *quod fuerit erunt horae perfectionis detectionis,* si deus voluerit.

1: The factor 7/56 (=1/8, if the readings are accepted) is obscure, and so it was to Ibn Almuthanna (Millás p.195).

2: "large table" Goldst., "tabulam maximam", Hugo (Cambr. Gonv.& Caius 456 p.155; Millás is faulty here). -- The table has not been found, but it need not have been large at all (cf. Goldstein's reconstruction p.240), so the present reading is likely to be the one intended.

Mora autem non erit soli cum fuerit eclipsis, nisi secundum spatium quo videtur, nec erit ei quantitas ex horis. Haec sunt igitur tria tempora: primum initium, secundum medium eclipsis, tertium perfectio detectionis, si deus voluerit.

(Solar eclipses: Figure.)

(Oo173 Q84) § Et *cum volueris figurare* hoc, *accipe quantitatem dimidii utriusque* quantitatis *per circinum, et fac circulum,* qui erit circulus*[a]* maior.[1] *Postea accipe quartam* partem quantitatis *circuli solis per circinum,* et *pone unam summitatem eius super cuspidem circuli, et fac circulum in medio[b] circuli maioris, qui erit circulus[c]* [maior] *solis.* Deinde *divide utrosque circulos per duas lineas, abscidat*que una earum aliam *super cuspidem* utrorumque circulorum; et *scribe super* summitates *linearum* orientem et occidentem, meridiem et septentrionem. *Postea accipe dimidium latitudinis lunae ordinatae per circinum, et pone unam summitatem eius in cuspide* utrorumque circulorum *et aliam* super diametrum quod est inter *meridiem* et *septentrionem,* in parte scilicet qua fuerit *latitudo* lunae ordinata, et scies *quo pervenerit, et signabis* locum. Deinde *accipe quartam circuli lunae per circinum[d], et pone unam summitatum eius super* ipsum *signum, et fac circulum,* qui*[e]* erit circulus *lunae;* et quod intraverit de *circulo* solis in circulum lunae, illud *est quod obscurabitur* de eo, si deus voluerit.

(**Revolutions of years.** *Other witnesses:* Oo174-180 are also in ms. Pz, 99va-100r; Mb,67va-68rb; Lx,155r-156r. The rest of the text printed here, until Oo212, corresponds with Cb, as indicated to each paragraph.)

(Oo174[2] Cb225) § Cum volueris scire quando intrabit sol vel luna aut aliquis*[a]* planetarum quem volueris*[b]* minutum quod volueris, considera diem quae fuerit prior*[c]* eidem horae, et aequa planetam ad medium diem, et scito buth eius; scito quoque horas diei tui et horas noctis tuae atque*[d]* horas medii diei tui*[e]*. Postea accipe longitudinem quae fuerit*[f]* inter planetam et minutum quod volu-

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1: The "circulus maior" has a radius equal to the sum of the radii of the luminaries, handy from Oo163. Such a circle would be useful as locus of the centre of the moon at the beginning and end of the eclipse, and it is employed in this way, e.g., in Albattani c.55 or in Cb199. Here, however, someone may have thought it was meant to envelop the figure, like the "circulus maior" in Oo150, and may have halved all the other measures in order to make the diagram fit within it. The halving is also attested from both versions of Q84.

2: This paragraph is not in Q. Oo175-76 seem to refer to it, but confirmation from Q is faint; see note to Q176.

eris, et divide eam per buth^g, et quod exierit erunt dies; quodque remanserit multiplica in XXIIII et divide quemadmodum divisisti^h, et quod exierit erunt horae, quodque^j remanserit pone minuta. Et quod exierit de diebus et horis atque minutis erunt dies longitudinis et horae eius: serva eos. Postea^k aspice: si planeta iam transierit minutum quod volueris, longitudo erit^l planetae; et si nondum transivit^m, erit longitudo^n gradus. Si autem fuerit longitudo planetae, minue dies longitudinis et eius horas de hora^o, id est de^p tempore, super quod aequasti planetam; si vero fuerit longitudo gradus, adde eas^q super praedictum tempus, secundum quod facis in coniunctione et praeventione; et quo perveneris, ipsa est hora in qua erit planeta in minuto quod voluisti, si deus voluerit.

(Oo175 Q85 Cb226) § Cum volueris *revolvere^a annos* nati vel *nativitatum^b*, *aspice quando intrabit sol minutum* in quo fuerit *in radice nativitatis;^{1}* et scito hoc secundum quod ostendi tibi in introitu solis in^c minutum quod volueris. Cumque *sciveris ipsam* horam, *constitue ascendens super eam* et domus atque planetas^d, quia hoc erit ascendens anni nati quem volueris. -- **(Oo176 Q Cb227)** *Si* autem *volueris revolvere annos mundi, aspice quando intrabit sol primum minutum^a arietis secundum hoc opus.^{2}* Et ipsa erit hora in qua revolutus est annus mundi; *constitue* itaque *super eam^b ascendens et domus* atque *planetas.* **(Oo177^3)** Et non velis operari in revolutione anni mundi horas diei, quia dies et nox tunc sunt aequales, duodecim scilicet^a horarum. Et scito quod buth solis, dum ingreditur arietem, est LVIII^b minuta et X'VIII^c secunda.^{4}

    (Oo178 Q86 Cb229) *Si* autem *volueris^a* hoc scire *alio modo^b*, aspice ascendens nati in radice, quot gradus sunt^c per gradus ascensionum eiusdem signi in regione qua ortus^d est natus, et serva eum. Post haec^e *accipe* quod *transierit de annis nati perfectis, et multiplica^f in XCIII gradibus et duobus minutis ac XV secundis, et adde desuper* quod ascenderit de *ascendente nati^5*. *Si* autem *quod collectum fuerit fuerit plus^g 360 gradibus, proice ex eis* 360; et

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1: "know that it may be any hour of the day or night", added in Goldst., similarly in Hugo.

2: "ad prescripte rationis ordinem", Hugo, not in Goldstein. This is the only corroborated reference to Oo174.

3: Not in Q or Cb.

4: The velocity of 58'48" is attested from Alkhwarizmi by Alhashimi, Haddad 1981, f.120r8, cf. p.298.

5: "the ascendant of the radix of nativity", Goldst., a remnant of the first period, which is missing in both versions? Millás merely has "natalis...gradus orienti<a>".

quod non perfecerit 360, id est quod fuerit infra, *proice[1]* eum *a* signo *ascenden-tis[h]* nati *per gradus ascensionis regionis* in quo fuerit natus. *Et quo perveneris,* erit *ascendens* per ascensiones[j]; verte eum *in gradus aequales.[2]* Et si volueris scire quantum transierit ex die de horis, si fuerit in die, vel de nocte, si fuerit[k] in nocte, scito hoc ab ascendente secundum quod exposui in[l] initio libri. -- Similiter fac in revolutione *anni mundi,* cum *sciveris ascendens[m] anni transacti.*

(**Oo179 Q87 Cb228**) *Si* autem *volueris hoc scire[a] alio modo, aspice quod transierit* ab ortu solis *diei nativitatis* usque in *horam[b] nativitatis de horis aequalibus,* et *serva eum. Post haec accipe annos nati perfectos, et multiplica eos in 2481, et divide quod collectum fuerit per 9600, et quod exierit erunt dies; et quod remanserit divide per 400[c],* et quod exierit erunt *horae;* et *quod remanserit multiplica in LX et divide per[d] 400, et quod exierit erunt minuta* unius *horae. Et adde* quod exierit de *diebus* et[e] *horis atque[f] minutis super diem et horam[g] nativitatis,* et *quo perveneris,* ipsa *erit //Oo,84r// hora revolutionis: constitue super eam ascendens.* -- (**Oo180 Q**) *Similiter* fac in revolutione anni[a] mundi, cum noveris horam *anni transacti:* omnia enim haec opera perducunt[b] ad unam rem. Si autem diversa fuerint adinvicem[c], iam[d] errasti: reitera numerum tuum[e], si deus voluerit, et ipse dirigat[f].

(**Computing sines for kardagas.** -- *Other witnesses:* Oo182-84 are also in ms. Mb,68rb; Lx,156r; Pz, 100r, in a slightly different version, not collated.

This section is likely to have several sources. Ibn Almuthanna has no trace of it at this place, but his exposition in Q35 furnishes a lot of parallels, not here noted in detail. The demonstration Oo187-96 may be ascribed to Ibn Almuthanna: indeed, he quotes himself for a demonstration like Oo187-92 (Q35 p.52:4-5; cf., however, note to Oo188), and Oo193-96 use the methods of Q35. On the other hand, Oo197-202 seem to duplicate Oo193-96 but use a different method, similar to Oo203-4 (see note to Oo198); thus, if anything, Oo197-204 are authentic. Oo205 is attributed to Alkhwarizmi, see note *ad loc.*

(**Oo181 Cb236**) § Abscisio[a] kardagarum sinus. Scito[b] quod sinus totus sit dimidium diametri circuli, qui est sinus XC. Et diametrum circuli est chorda CLXXX graduum, quia circulus totus est trecentorum sexaginta graduum. Et sinus uniuscuiusque arcus[c] est dimidium chordae duplicititatis eius, quemad-modum sinus XXX est dimidium chordae LX, et sinus XV est dimidium

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1: "subtract" Goldst.; rather, "extend this arc from (the beginning of) the sign rising at nativity, reckoning along the equator (=per gradus ascensionum)". Cf. Cb, and Hugo's "inter orientia eiusdem regionis invento".

2: The total arc is to be converted to an arc on the ecliptic (="in gradus aequales"). The phrase is absent at this place in Goldst., but resembles a phrase at the end of Q86 (in Goldst. and Hugo, absent here) on world-years.

chordae XXX; sinus quoque XLV^d est dimidium chordae XC; et^e sinus VII et dimidii est <dimidium> chordae^f XV; et similiter omnes sinus.

(Oo182 Cb238) Cumque volueris scire diametrum circuli, divide circulum, qui^a est 360 graduum, per tria [id est non ex toto iuxta numerum] et septimam unius, et quod exierit erit diametrum. Et non est in hoc necessitas, est autem aptatio. (Oo183 Cb239) Et est ei alius modus: multiplica circulum in semetipso, et divide quod collectum fuerit per X, et quod exierit, accipe radicem eius, et quod fuerit erit diametrum. (Oo184 Cb240) Est quoque ei et alius modus: multiplica circulum ^{a}in 20000^b et divide quod collectum fuerit per 62832^c, et quod^a exierit erit^d diametrum. (Oo185 Cb241) Scito igitur diametrum circuli, cum quo horum numerorum volueris. -- Cumque volueris abscidere kardagas sinus certissime, accipe dimidium^a diametri circuli, qui est sinus totus, et operare cum eo secundum quod exposui.

(Oo186 Q35a^1 Cb242) Si autem volueris abscidere eum aliter, non +ex+ impedit quin^a constitueris sinum ex ali[qu]o, quia, +omne quod+ feceris cum eodem sinu, necesse est ut reddas eum^b arcum, postquam acceperis quantitatem <eius ad sinum totum, ** est quantitas> sinuum abinvicem, arcubus et chordis non est quantitas abinvicem.^{2} +Quasi ergo poneremus+ diametrum 300 minutorum et sinum totum 150 minutorum.^{3}

(Oo187 Cb243) Et iam patuit nobis quod chorda VI'tae uniuscuiusque circuli sit similis medietati diametri eius. Et ad hoc fecimus iam figuram significantem eius probationem; et haec est figura^4:

1: Q35, p.51:21-24 (without ascription) occurs as a lemma in Millás p.124 and in Cambr., Gonv. & Caius 456, p.51. The present paragraph seems to be a digest of this and of some of the commentary following.

2: The paragraph is garbled, and all corrections are by way of example. The sense should be as in Ibn Almuthanna's commentary (Q35, p.51:24-39), "I say that there is no proportion at all between arcs and chords ... In computing sines to given arcs, the amount of the diameter does not matter, since the chords are derived from the diameter and have a fixed ratio to it. In converting sines back to arcs, it also does not matter...". Cf. also Albattani ch.3. - Cb242 depends on our text, but does not give the sense required.

3: Either like "The Hindus considered the diameter as 300 parts" (Q35, p.51:26), or a false start resembling Oo193 or Oo197.

4: Drawn from the description below, aided by Cb243, where the mss. show a figure very similar to the one here presupposed. Ms.Oo has a figure, but this only comprises the circle ABGD and the lines and circles inside it.
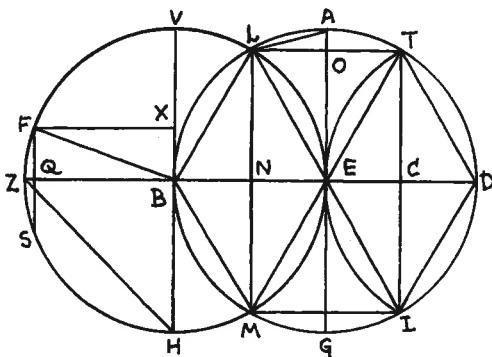
(Oo188 Cb244) Cuius rei probatio est quod facimus circulum, qui est circulus ABGD, quem quadrabimus duabus lineis se invicem abscidentibus super cuspidem, qui est punctus E; lineae vero sunt lineae AG et BD. Deinde ponimus circinum super punctum B et facimus circulum contingentem lineam AG super punctum E, qui est circulus VZH[a]. Iterum ponemus circinum super punctum D et faciemus circulum contingentem lineam AG super punctum E, qui est circulus TI.

Patuitque nobis quod circulus ABGD, dum abscideret circulum VZH super punctum L et M, quod arcus LBM[b] de circulo ABGD <**(Oo Cb245)**>[1] sit similis arcui LE, et arcus BM similis arcui ME. -- (Oo189 Cb) Iamque patuit quod linea EB sit dimidium diametri circuli; et est similis <lineae ME **; et est similis> lineae EL, quia est etiam dimidium diametri circuli; et lineae[a] LB, dimidii diametri circuli etiam; et est similis lineae BM. Et linea ME et EL et LB et BM sunt chordae IIII'or arcuum. Iamque patuit quod arcus sint aequales, quia[b] chordae similiter aequales.[2]

(Oo190 Cb246) Et patuit[a] quoque <quod> linea LM abscidit lineam EB per medium eius super punctum N; linea igitur NE[b] est quarta diametri circuli. Et linea TI abscidit lineam DE per medium super punctum C: linea quoque EC[c] est quarta diametri circuli, et est similis NE. Iam igitur patuit quod linea NC[d] sit dimidium diametri circuli, (Oo191 Cb247) et quod sit similis lineae MI[a] et similis lineae LT[b], et est dimidium diametri. Patuit quod arcus MI[c] et arcus

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1: Cb has "et portio LBM circuli ABGD est aequalis portioni *MEL circuli VZH.* (Cb245:) *Demonstratur etiam quod portio LB sit aequalis portioni* illi quae est LE". This may correspond to the statement Ibn Almuthanna ascribes to Alkhwarizmi, Q35 p.52:14.

2: "quia -- aequales": Oo has "(et) corde simil(ite)r equales". The intent is to show that the arcs are equal since the chords were equal. -- Cf. Cb245: "demonstratur ... quod lineae ME et EL et LB et BM sint 4 chordae 4 portionum circuli aequalium, *quia illae* (=chordae) *sibi sunt aequales*".

LT^{d1}, unusquisque eorum scilicet, sit similis arcui BM, quia chordae eorum sunt similes chordae eius, et omnes sunt ex uno circulo. Et arcus DI similis arcui DT.

(Oo192 Cb248) Iamque factus est circulus totus VI arcus aequales; et <patuit quod> chorda uniuscuiusque arcus^a sit similis diametri circuli dimidio. -- Et patuit quod chorda sextae uniuscuiusque circuli sit similis medietati^b diametri circuli eius; et hoc est quod voluimus patefacere.

(Oo193 Cb249) Cumque posuissemus diametrum circuli 300^a minuta, patuit quod chorda 60 sit CL; et sinus XXX, septuaginta V, quod est dimidium lineae MI^b; et quod sinus LX linea MN, et <est dimidium> chordae^c 120^d, <quae> est linea LM.

(Oo194 Cb250) Et extendimus a puncto Z^a in punctum H lineam quae est chorda quartae partis circuli, qui sunt XC^b gradus; et chorda est radix quadraginta V milium, cuius medietas est sinus quadraginta quinque, quae est radix XI milium et ducentorum quinquaginta.

(Oo195 Cb251) Et iam patuit quod a puncto A in punctum L sit arcus dimidii sextae partis circuli, qui sunt XXX'ta gradus. Et scientia eius chordae est ut multiplices sinum XXX in semetipso, quae est linea LO, et multiplices lineam AO in semetipsam -- hoc est ut minuas sinum^a LX de medio diametri, et quod remanserit erit linea AO -- et colliges eum ad multiplicatum lineae sinus^b XXX in semetipsa, et accipias radicem eius: quod collectum fuerit erit chorda XXX, cuius medietas est sinus XV.

(Oo196 Cb252) Post haec redibis a puncto Z^a in utrisque quartis circuli [in utraque scilicet parte] quae succedunt HV, ex omni parte scilicet XV gradus, eritque^b horum universitas XXX gradus, a puncto scilicet F in punctum S; iungesque quod est inter F et S per lineam, quae erit chorda huius arcus qui est XXX graduum. Patuitque quod linea FS^c sit similis lineae AL, et quod medietas eius sit linea FQ, sinus scilicet XV; et linea QS similiter sinus XV.

Patuit quoque quod arcus qui est inter F <et> V [<ve>l <inter S et H>, unusquisque^d //Oo,84v// scilicet eorum,] sit septuaginta V graduum, et quod sinus huius sit quod est inter^e Q et B. Et scientia huius rei est quod linea FB^f sit dimidium diametri, quod est 150 graduum. Multiplica igitur 150 in semetipsis et sinum 15, quae est linea FQ, in semetipso, et minues de linea FB multiplicata^g in semetipsa, et quod remanserit, accipe radicem eius, quae erit linea QB, et est sinus 75; et est similis lineae XF, quae^h est dimidium chordae 150. Similiter fac quicquid^j fuerit, exiguum sive^k plurimum, de sinu.

1: "MI", "LT", twice: Oo reads "MB", "LE", and Cb has "MB", "LT".

(**Oo197 Cb253**) Cumque posuissemus diametrum 300 minuta, novimus quod chorda VI'tae partis circuli, qui fuit^a 60, sit 150, quod est dimidium diametri, et est sinus totus; cuius medietas est sinus XXX, et est septuaginta V, qui est sinus duarum kardagarum.

(**Oo198 Cb254**) Multiplica ergo sinum XXX in semetipso, et minue eum de sinu toto multiplicato in semetipso, et accipe radicem eius quod^a remanserit, et quod fuerit erit sinus 60, qui est IIII^b kardagarum, et est dimidium chordae 120.

Minue itaque eum de sinu toto, et multiplica^c quod remanserit in 75^d, et pone quod collectum fuerit in duobus locis. Et accipe radicem unius locorum, et quod fuerit <erit> sinus 15, quae est kardaga I'a. (**Oo199 Cb255**) Et minue alium locum de sinu toto multiplicato in semetipso -- qui est 150 minuta in semetipsis, eritque hoc 22500 -- et quod remanserit, accipe radicem eius, et quod fuerit erit sinus 75^a, qui est V kardagarum, et est dimidium chordae 150.^{1}

(**Oo200 Cb256**) Et minue sinum XV de sinu XXX, et quod remanserit erit kardaga secunda.

(**Oo201 Cb257**) Postea accipe sinum totum, et multiplica eum in semetipso, et dupla eum, et accipe radicem eius; quod collectum fuerit erit chorda XC. Accipe medietatem eius, et erit sinus 45, qui est trium kardagarum.

(**Oo202 Cb258**) Minue ex eis sinum^a duarum kardagarum, et quod remanserit erit kardaga tertia. Deinde minue sinum trium kardagarum de sinu LX, qui est IIII'or kardagarum, et quod remanserit erit kardaga IIII'ta. Et minue sinum IIII'or kardagarum de sinu 75, qui est V kardagarum, et quod remanserit erit kardaga <V'ta. Et minue sinum V kardagarum de sinu toto, et quod remanserit erit kardaga>^{2} VI'ta.

Hae sunt VI kardagae^b, si deus voluerit.

(**Oo203 Cb259**) § Si autem volueris abscidere eas ad minus, accipe kardagam VI'tam et multiplica eam in sinum XXX, et pone quod collectum fuerit in duobus locis. Et accipe radicem unius locorum, et quod fuerit erit sinus VII et dimidii. Et minue alium locum de sinu toto multiplicato in semetipso, et accipe radicem eius quod remanserit, et quod fuerit erit sinus 82^a et dimidii.

1: Thus (since Sin 60° = Cos 30°), Sin² 15° = (R/2) (R - Cos 30°), and Sin² 75° = Cos² 15° = R² - Sin² 15°. This method is also used in Oo203, but differs from the one prescribed in Oo195, though this stands as if intended to illustrate the present passage. On the other hand, Cb254, parallel to the present paragraph, seems to be modelled on Oo195 (Cb251).

2: Supplemented from Cb.

Deinde minue sinum 82 et dimidii de 150, qui est sinus totus, et multiplica quod remanserit in sinu XXX, et pone quod collectum fuerit in duobus locis. Et accipe radicem unius locorum, et quod fuerit erit sinus[b] trium graduum[c] et 45 minutorum. Et minue alium locum de 22500, et quod remanserit, accipe <radicem> eius, et quod fuerit erit sinus 86 et quartae.

Postea minue sinum 45 de sinu toto, et multiplica quod remanserit in sinu XXX, et pone quod collectum fuerit in duobus locis. Et accipe radicem unius eorum, et erit sinus 22 et dimidii. Et minue alium locum de sinu toto multiplicato in semetipso, et accipe radicem eius quod remanserit, et quod fuerit erit sinus 67 et dimidii. [Minue alium locum de sinu toto multiplicato in semetipso, et accipe radicem eius quod remanserit, et quod fuerit erit sinus 63 et dimidii.]

(Oo204 Cb) Minue itaque eum[a] de sinu toto, et multiplica quod remanserit in sinu XXX, et pone eum in duobus locis. Et accipe radicem unius eorum, et erit sinus 11 et quartae. Et minue alium locum de sinu toto multiplicato in semetipso, et accipe radicem eius quod remanserit, et erit sinus 78[b] et trium quartarum[c].

Postea minue sinum 15 de sinu toto, et multiplica quod remanserit in sinu XXX, et pone eum in duobus locis. Et accipe radicem unius eorum, et quod fuerit erit sinus 37 et dimidii. Et minue alium locum de sinu toto multiplicato in semetipso, et accipe radicem eius[d] quod remanserit, et quod fuerit erit sinus 52 et dimidii. -- Similiter fac cum universis gradibus usque quo volueris.

(Oo205 Q35b[1] Cb260) § Abscisio kardagarum declinationis.

Cum volueris abscidere kardagas *declinationis ad singulos gradus* vel ad plus sive ad minus usque in perfectionem nonaginta graduum -- quia declinatio horum graduum erit aequalis; et quicquid transierit XC usque in perfectionem 180, erit declinatio eorum versa; quicquid transierit quoque 180 usque 270, erit declinatio eorum 90 similis[a] primae; et usque in perfectionem 360, erit declinatio horum[b] XC versa -- cumque volueris hoc scire ad singulos gradus vel ad minus vel ad plus, *accipe declinationem totam,* et pone eam *sinum,* et serva. Post haec *accipe gradum cuius declinationem scire volueris,* sive unus fuerit vel plures, et pone eum *sinum,* et *multiplica* eum in *sinu totius declinationis, et quod collectum fuerit divide per* 150, et pone quod exierit arcum; et *quod exierit*

1: Q35, p.64:30-65:1 "Our calculation for declination follows Al-Khwarizmi's instructions". The passage is a lemma in Hugo, Millás p.132.

de arcu erit declinatio gradus quem volueris. Similiter facies cum universis gradibus usque in perfectionem 90 graduum, si deus voluerit.

(**Hours from altitude:** Day-arc for stars (Oo206-07); Finding time of night (Oo208-12). *Other witnesses:* Oo206-7 are also in ms. Pz,99vb; Mb,68rb-va; Lx,156v: heading, "de inveniendo die (inv'da quantitate diei Pz) cuiuslibet stellarum". -- This whole section, Oo206-12, shows much coincidence with Albattani c.18-21 (p.31-34 Nallino I).

Oo206-07 are not in Q, and Oo206 overlaps with Oo208 (in the counterpart of Oo208, Cb232, the overlap has been exchanged for a "sicut supra docuimus"; intriguingly, the same is the case in Albattani). However, the beginning of Oo209 presupposes a canon for day-arc, and only Oo206-7 seem to fit.

Goldstein's text is absent here, having left off abruptly within Q87 (cf.Oo180), so Ibn Almuthanna is only represented by the Hugo version. I refer to the lemmas as follows: Q88, p.201 Millás; Q89-90, p.202; Q91-92, p.203; Q93, p.204.)

(Oo206 Cb230) § Cum volueris scire longitudinem diei planetae.

Cum volueris scire longitudinem diei uniuscuiusque gradus quem volueris de circulo, vel uniuscuiusque stellae quam volueris, tam ex stellis fixis quam ex V planetis, in quacumque^a regione volueris^b, accipe longitudinem planetarum de^c linea aequinoctiali. ^{d}Et scientia huius rei est ut aspicias gradum planetae, in quo est ex longitudine, et scias declinationem eius et partem^d declinationis, ac serva. Postea scito latitudinem planetae et partem eius. Et si fuerint^e declinatio et latitudo in una parte, iunge utrasque; si vero fuerint diversae, minue minorem de maiori ^{f}et scito partem eius; et quod fuerit^f erit longitudo planetae a linea^g aequinoctiali. Si autem volueris hoc de gradu solis, accipe^h ^{i}declinationem gradus, quae est longitudo eius^j a linea^k aequinoctiali, quia sol caret latitudine.^{l}

Cumque volueris scire arcum diei planetae vel gradus, accipe longitudinem eius a linea aequinoctiali, et pone eam sinum, et serva^l. Deinde minue longitudinem de XC, ^{m}et pone quod remanserit sinum, et^m serva;^{n} accipe quoque latitudinem regionis in qua^p fueris, et^q pone eam sinum, et^r serva; et minue latitudinem de XC, ^{s}et pone quod remanserit sinum, et^s serva.

(Oo207 Cb231) Post haec multiplica^a sinum latitudinis regionis in sinum longitudinis [eius] a linea^b aequinoctiali, et divide quod collectum fuerit per^c sinum perfectionis longitudinis^d de XC; et iterum multiplica^e quod exierit^f in 150, et divide per sinum perfectionis latitudinis regionis, et pone quod exierit arcum; et quod exierit de arcu, dupla. Post haec aspice: si fuerit longitudo planetae a linea aequinoctiali septentrionalis, adde arcum, qui exivit tibi^g, super 180; et si fuerit longitudo meridiana, minue eum de 180^h; et quod fuerit post

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1: Here Cb adds a reference to the Toledan tables of stellar coordinates (T82).

augmentum vel diminutionem, erit arcus diei planetae vel gradus quem volueris. Divide eum per 15, et quod fuerit erunt horae diei eiusdem^j planetae vel gradus ex quo oritur donec occidat^k. Divide quoque arcum diei eius^l per XII^m, et quod fuerit erunt partes horarum eius, si deus voluerit^n. //Oo,85r//

(Oo208 Q88 Cb232) § Scientia horarum quae transierint in nocte per probationem stellarum fixarum.

Cum volueris scire quid *transierit ex nocte de horis, proba quamcumque* stellam volueris ex stellis *fixis, et serva altitudinem eius; et* scito *locum* planetae in signo suo et gradum eius, *latitudinem quoque* eius *et partem* eius. *Postea accipe declinationem gradus* planetae, *et* scito *partem* declinationis. Deinde aspice: *si* fuerit *declinatio* gradus planetae^a <*et latitudo*> *in una parte, iunge* utrasque, et *si fuerint^b diversae, minue minorem de maiori* et scito *partem* eius; et quod fuerit *erit longitudo* planetae *a linea aequinoctiali, et serva* eum^l. (Oo209 Q89 Cb) *Scito quoque arcum diei* planetae et *arcum* diei *gradus* planetae, et *minue minorem de maiori, et quod remanserit, accipe medietatem* eius, et erit *quantitas* quae est *inter^a utrosque dies. Postea accipe ab ariete in* gradum planetae *per* gradus *ascensionum,*^{2} et serva eum. Deinde aspice: *si* fuerit *arcus diei* planetae^b *plus arcu^c diei gradus eius, minue quantitatem* [eius], quae est *inter utrosque dies,*^{3} *de eo quod servasti* ab ariete in gradum planetae per ascensiones; ^{4}et si fuerit quantitas diei planetae minus quantitate^d diei gradus eius, *adde quantitatem,* quae est *inter* utrosque dies, *super* illud quod servasti ab ariete in *gradum* planetae per *ascensiones.* Et quod fuerit post augmentum vel diminutionem, arcua eum secundum quod ostendi tibi in opere arcus,^{5} hoc est ut vertas eum in gradus aequales; et quo pervenerit, erit gradus qui orietur cum eo: serva eum.

(Oo210 Q90 Cb233) *Postea* aspice: si fuerit *longitudo* planetae *a linea aequinoctiali septentrionalis, adde* longitudinem planetae a linea aequinoctiali *super altitudinem arietis regionis in^a qua fuit;* et si fuerit *meridiana, minue^b* eam de ea; et quod^c fuerit post augmentum vel diminutionem, *erit altitudo medii diei* planetae *in eadem regione.*

1: "cuius *partis* sit notato", Hugo.

2: "per orientia *terre*", Hugo.

3: "utriusque diei *mediam* distantiam", Hugo: the halving was done just above, so this mention is redundant.

4: The rest of Oo209 corresponds to the end of Q89 (p.202 Millás), "et ideo videtur sic praecepisse...".

5: Referring to Oo86 or Oo88, not printed here but resembling Cb95 / Cb97.

(**Oo211**[1] **Q91 Cb234**) Post haec accipe *dimidium arcus diei* planetae, et *pone* eum[a] *sinum versum*[b]; accipe quoque *altitudinem* planetae in *hora probationis*, et *pone* eam *sinum*, et *multiplica* eum[c] in sinu dimidii arcus diei verso, et *divide per sinum altitudinis medii diei* planetae, et *minue quod exierit de sinu medii* arcus *diei verso*[d], quodque *remanserit pone arcum versum*, et quod exierit *serva*. Postea aspice: *si* fuerit planeta, dum *probasti* eum, inter orientem et medium caeli,[2] *minue* quod exierit tibi *de dimidio arcus diei* planetae; et *si* fuerit inter medium caeli et occidentem, *adde* eum super dimidium arcus diei planetae[e]; et *quod fuerit* postea, ipsum est *quod abierit de circulo ex quo ortus est* planeta usque *in horam probationis*.

(**Oo212 Q92 Cb235**) Deinde aspice *gradum, cum quo oritur* planeta: si fuerit *inter gradum solis* et *eius nadir,* ortus est planeta in *die;* et si fuerit *inter nadir* et *gradum solis, ortus* est in *nocte*. (**Oo Q93 Cb**) *Si* autem *ortus* est planeta in *die, accipe a gradu cum quo ortus est* planeta usque *in nadir* gradus *solis per* gradus *ascensionis*, et quod fuerit, *minue* eum *de* eo quod servasti, de eo scilicet quod[a] indicaverit *quod abierit de circulo;* et quod remanserit, ipsum est quod abierit de circulo ex quo occidit sol usque in horam probationis. Et *si* ortus fuerit *in nocte, accipe a nadir gradus solis* usque *in* gradum *cum quo ortus est* planeta, et *adde* quod fuerit super illud *quod abierit de circulo, ex quo ortus est;* et <quod fuerit>, ipsum est *quod abierit*[b] <*de circulo*> *ex quo occidit sol* usque *in horam probationis. Divide* eum *per partes horarum noctis* tuae, et quod fuerit, ipsum est quod transivit in nocte de horis *inaequalibus*[c]; si vero volueris horas aequales, divide eum *per 15*, et *quod exierit erunt* horae *aequales*[d] transeuntes de nocte. Et si volueris scire ascendens, operare[e] cum eo quemadmodum dixi tibi in opere constitutionis ascendentis,[3] si deus voluerit[f].

Variant readings

(**Oo123**) a: divide Oo.ac || b: eam Oo || c: *s.l.* Oo || (**Oo124**) a: earum Oo.ac || b: eiuscumque Oo || c--c: *in ras. aut in mg.* Oo || p.e.: *n.l.* Oo || (**Oo125**) a--a: *bis scripsit* Oo (=Oo1, Oo2) || b: q.s.f.: quod si remanserit Oo2 || c: ses Oo1 || d: vi Oo1 || e: *om.* Oo1 || (**Oo126**) a: Pz; albuth Mb Lx; buhz Oo || b: Oo; sed Pz Mb Lx || c: Pz; albuth Mb Lx; buz Oo || d: s.h.: Pz Mb Lx; ad h.s. Oo || e: Pz Mb Lx; *om.* Oo || f: Oo: predicto Pz Mb Lx || g: a.t.f.: f.a.t. Oo; vero t.f. (+tibi Mb) Pz Mb Lx || h: Oo; *om.* Pz Mb Lx || j: Pz Mb Lx; *om.* Oo || k: Oo; post hec (hoc Mb) Pz Mb Lx || l: Pz; buthz Oo; buth Mb Lx || (**Oo127**) a: -b() Oo

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1: Oo211 has almost the same text as Oo101 (cf. Q50, Cb111).

2: "si fuerit planeta...": "si *ante meridiem* haec existimatio fuerit", Hugo, and correspondingly below.

3: Oo103-107, corresponding to Cb112-15.

|| **(Oo128)** a: Oo.pc || b: d.n. Oo || c: -zehar Oo || d: f.d.: fuerit diuisi Oo || **(Oo130)** a: fuerit Oo || **(Oo132)** a: alt- Oo || b: alt- Oo || c: *s.l.* Oo || d: xv Oo || **(Oo133)** a: Pz Mb Lx; numeris Oo || b: Pz; uidebi()t Oo; -b(itu)r Pz; -buntur Mb Lx || **(Oo134)** a: buh Oo.ac || b: Oo; *om.* Pz Lx; *def.* Mb || c: numerum Oo; minutum Pz; minimum Lx Mb || d: Pz Mb Lx; s(ed) d(icitur) Oo || e: s.d.v.: Oo; *om.* Pz Mb Lx || **(Oo136)** a: but Oo || b: but Oo || c: a.d.: *s.l.* Oo || **(Oo137)** a: re addideris Oo || **(Oo138)** a: ea Oo || **(Oo139)** a: +post Oo || b: +et quod Oo || **(Oo140)** a: addisti Oo || b: lunam Oo.ac || c: lineam Oo || **(Oo141)** a: geuuz[[i]]\a/bar Oo || b: +in Oo || c: utrum Oo || d: medie Oo.ac || **(Oo142)** a: mara Oo || b: mara Oo || c: divisti Oo || **(Oo143)** a: eum Oo || b: de minuto Oo || **(Oo144)** a: -lis Oo || b: eam Oo || c: erit q(uod) Oo || d: delectionis Oo *(!), hic et saepissime* || **(Oo145)** a: eum Oo || **(Oo146)** a: augmentum Oo || **(Oo147)** a: augmento Oo || b: minuto Oo || **(Oo148)** a: *s.l.* Oo || b: -nes Oo.ac || c: accipe Oo || d: eum Oo || e: +in Oo || f: minuto Oo || **(Oo149)** a: -cens- Oo || b: hore Oo || **(Oo150)** a: tm() Oo || b: circulum Oo || c: unum Oo || d: circuli Oo || e: circulum Oo || **(Oo151)** utrumque Oo.ac || b: quantitatem Oo.ac || c: -alu(er)t(ur) Oo || **(Oo152)** a: circuli Oo || **(Oo153)** a: circulum Oo || b: in t.: initium Oo || c: quod Oo || d: quod Oo || **(Oo154)** a: vi Oo || b: a.e.p.4: < <per> > iiii a.e. Oo || **(Oo155)** a: accipe Oo.ac || b: super Oo.ac || **(Oo156)** a: unius h. unum gr.: unum gr. unius h. Oo || b: +quatuor Oo || **(Oo157)** a: est Oo || b: visionis Oo || **(Oo158)** a: q(uod) Oo || b: ca() Oo || c: equales Oo || d: horas Oo || e: equales Oo || f: q(uas)i Oo || g: visionis Oo || h: i(n)t()m Oo || **(Oo159)** a: t()i Oo || b: s.a.m. Oo.ac || **(Oo160)** a: -tis Oo || b: declin()o Oo || c: serva Oo || **(Oo161)** a: fuerit Oo || b: -ri Oo || c: eam Oo || **(Oo162)** a: sumere Oo || b: -b() Oo || c: si Oo || d: -is Oo || e: altitudo Oo || f: quod Oo || **(Oo163)** a: +c (!) Oo || b: alti- Oo || c: *mg.* Oo || **(Oo169)** a: quam Oo || b: -sio Oo || c: diversio Oo || d: aspe Oo.ac || e: *vel* 3530 Oo || f: demersio Oo || **(Oo170)** a: -ea(m) Oo || b: +quod Oo.ac; +quod colligitur Q || **(Oo171)** a: -la Oo || **(Oo172)** a: -es Oo || **(Oo173)** a: -lo Oo || b: -ium Oo.pc || c: -l(is) Oo || d: circulum Oo || e: s.q.: signum quod Oo || **(Oo174)** a: a.a.: Oo; vel quisque Pz Mb Lx || b: q.v.: Oo; *om.* Pz Mb Lx || c: q.f.p.: Oo; qui prior sit Pz Mb Lx || d: h.n.t.a.: Oo; noctis et Pz Mb Lx || e: m.d.t.: mediei tui Oo; medii diei Pz Mb Lx || f: Oo; est Pz Mb Lx || g: Oo; +planete Pz Mb Lx || h: Oo; quo prius Mb Pz.ac; quoque prius Lx; ut prius Pz.pc || j: Oo; et quod Pz Mb Lx || k: Oo; post hec Pz Lx; post hoc Mb || l: Oo; e.l. Pz Mb Lx || m: e.s.n.t.: Oo; si vero non Pz Mb Lx || n: e.l.: et e.l. Oo; l.e. Pz Mb Lx || o: d.h.: Pz Mb Lx; dierum Oo || p: Oo; +anni Pz Mb Lx || q: eam Oo Pz Mb Lx || **(Oo175)** a: Pz Mb Lx; volvere Oo || b: Pz Mb Lx; +annos Oo || c: Pz Mb Lx; *om.* Oo || d: Mb Lx; -ta Oo Pz || **(Oo176)** a: Pz Mb Lx; initium Oo || b: eum Pz Mb Mc; erum Oo || **(Oo177)** a: 12 s.: Oo; s.12 Pz Mb Lx || b: Pz Oo; lviiii Mb Lx || c: (=48): xlviii Lx; xv.iii Oo; (48) Pz Mb || **(Oo178)** a: Oo; v.a. Pz Mb Lx || b: Oo; a.m.s. Pz Mb Lx || c: Oo; sint Pz Mb Lx || d: Pz Mp.pc Lx; oritur Mb.ac; [[a]]totus Oo || e: p.h.: Oo; postea Pz Mb Lx || f: Oo; +eos Pz Mb Lx || g: f.p.: Oo; p.f. Pz Mb Lx || h: Pz Mb Lx; -ntes Oo || j: Pz Mb Lx; -onis Oo || k: d.n.s.f.: Pz Lx; d.n. et s.f. hoc Mb; *om.* Oo || l: Mb Lx: *s.l.* Pz; *om.* Oo || m: Pz Mb Lx; -dentes Oo || **(Oo179)** a: Mb Lx ?Pz; *om.* Oo || b: Pz Mb Lx; hora Oo || c: +400 Oo || d: Pz Mb Lx; *om.* Oo || e: Pz Mb Lx; *om.* Oo || f: Oo; et Pz Mb Lx || g: e.h.: Pz Mb Lx; *om.* Oo || **(Oo180)** a: +di Oo(!) || b: Pz Mb Lx; prod- Oo || c: f.a.: Oo; a.f. Pz Mb Lx || d: Oo; *om.* Pz Mb Lx || e: n.t.: Oo; ut cognoscas Pz Mb Lx || f: e.i.d.: Oo; *om.* Pz Mb Lx || **(Oo181)** a: ascensio Oo || b: cito Oo || c: gradus Oo || d: *in ras.* Oo || e: *om.* Oo.ac || f: corda Oo || **(Oo182)** a: q(ui)/q(uod) Oo || **(Oo184)** a--a: *delevit Oo et in mg. sup. ascripsit* multiplica circulum per 20000 et divide per 62832 et quod proveniet ex hac divisione erit diametrum || b: 30000 Oo || c: 63822 Oo || d: *om.* Oo.ac || **(Oo185)** a: dimimidium Oo || **(Oo186)** a: quicquid Oo || b: +sinum Oo.ac ||

(Oo188) a: v (et) h Oo || b: lb Oo.pc || **(Oo189)** a: linea Oo || b: et Oo || **(Oo190)** a: ponit Oo || b: nb Oo || c: l.q.e.: *in ras. aut in mg.* Oo || d: ne Oo.ac || **(Oo191)** a: mb Oo || b: le Oo || c: mb Oo || d: le Oo || **(Oo192)** a: circuli Oo || b: *s.l.* Oo || **(Oo193)** a: 360 Oo || b: mb Oo || c: corda Oo || d: 130 Oo.ac || **(Oo194)** a: (et) Oo || b: xv? Oo.ac; 90 Oo.pc || **(Oo195)** a: +xxx Oo || b: sin. lin. Oo || **(Oo196)** a: (et) Oo || b: erit q(uod) Oo || c: bs Oo || d: hun- Oo || e: ter Oo || f: sb Oo || g: -plica Oo || h: s() Oo || j: qcq(uid) Oo || k: sin(um) Oo || **(Oo197)** a: fu(er)it Oo || **(Oo198)** a: +(et) Oo || b: (et) iii Oo || c: +et Oo || d: 25 Oo || **(Oo199)** a: 35 Oo || **(Oo202)** a: -us Oo || b: gardage Oo || **(Oo203)** a: 83 Oo || b: sima Oo || c: kardagarum Oo || **(Oo204)** a: ea Oo || b: 28 Oo || c: equatarum Oo || d: +et Oo || **(Oo205)** a: s. 90 Oo || b: huius Oo || **(Oo206)** a: Pz Mb Lx; qualicumque Oo || b: Oo; *om.* Pz Mb Lx || c: Oo; a Pz Mb Lx || d--d: Oo; partem scilicet Pz Mb Lx || e: Mb; fuerit Pz Lx Oo || f--f: et s.p.e. et quod remanserit et q.f. Oo; et residuum Pz Mb Lx || g: a l.: Oo; ab Pz Mb Lx || h: Pz Mb Lx; *om.* Oo || j--j: Oo; eius declinationem Pz Mb Lx || k: a l.: Oo; ab Pz Mb Lx || l: Oo; +eam Pz Mb Lx || m--m: Oo; residuum pro sinu Pz Mb Lx || n: +postea minue longitudinem de xc et pone sinum (!) quod remanserit sinum et serva Oo; +postea minue latitudinem de 90 et residuum serva pro sinu Pz || p: Pz Mb; quo Lx Oo || q: Oo; *om.* Pz Mb Lx || r: Oo; ac Pz Mb Lx || s--s: Oo; residuum pro sinu Pz Mb Lx || **(Oo207)** a: Oo; duc Pz Mb Lx || b: Oo; ab Pz Mb Lx || c: q.c.f.p.: Oo; c. in Pz Mb Lx || d: Pz Mb Lx; *om.* Oo || e: Oo; duc Pz Mb Lx || f: q(uod)q(uod) e. Oo; residuum Pz Mb Lx || g: e.t.: Oo; exierit Pz Mb Lx || h: e.d.180: eam de 180 Oo; *om.* Pz Mb Lx || j: Oo; *om.* Pz Mb Lx || k: -derit Oo.ac || l: Oo; *om.* Pz Mb Lx || m: xli Oo; 12 Mb; xv Pz; *vac.* Lx || n: Oo Lx; invenire concesserit (censenserit Mb) Pz Mb || **(Oo208)** a: p.g. Oo || b: fuerit Oo || **(Oo209)** a: in Oo || b: plus Oo.ac || c: a.p. Oo.ac || d: m.q.m.q. Oo || **(Oo210)** a: i.r.a. Oo.ac || b: +e Oo(!) || c: q(uem) Oo || **(Oo211)** a: eam Oo || b: -si Oo || c: eam Oo || d: -si Oo || e: -ta Oo || **(Oo212)** a: s.q.: s(e)c(un)d(u)m quo Oo || b: i.e.q.a.: q.a.i.e. Oo || c: equ- Oo.ac || d: inequ- Oo || e: opera Oo || f: -ris Oo