Jean des Murs's *Canones tabularum Alfonsii* of 1339

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Abstract

Among the works by Jean des Murs that have yet to be printed are his *Canones tabularum Alfonsii*, which he wrote in 1339 during his last attested stay at the Collège de Sorbonne. One element of particular interest in this concisely worded text is Jean's discussion of the length of the solar year, which was the first to take into consideration the consequences of the Alfonsine precession model for the length of the tropical year. Another is his approach to finding the time of true syzygy, which can be compared with some of his earlier writings on the same topic. Taken together, these writings reveal something about Jean's development as an astronomer over time, as he adjusted his preferred method of syzygy computation in reaction to empirical data. The article concludes with a look at the chapters devoted to the calculation of eclipse times and magnitudes, which turn out to be strongly influenced by John of Genoa's *Canones eclipsium*, written in 1332.

Keywords

Jean des Murs; John of Genoa; Alfonsine Tables; University of Paris; Collège de Sorbonne; medieval astronomy; astronomical tables; eclipses

Introduction

One recurrent feature of Jean des Murs's quadrivial texts are the explicit references to his presence at the Collège de Sorbonne, founded in 1257. The earliest known hint at Jean's ties to this Parisian college appears in the brief canon accompanying his *Kalendarium solis et lune*, which Jean brought to fruition in 1321 'while staying at the poor students' hostel of Sorbonne' (*commorans in domo pauperum scolarium de Sorbona*).[1] The Collège is mentioned again as a place of writing in colophons attached to Version A of Jean's *Musica speculativa* (1323) and to his *Arbor Boethii* (1324).[2] Further evidence comes from Jean's autograph notes in the famous Escorial codex, which reveal that he was on site on 29 March 1337 to observe a conjunction of Saturn and Mars.[3] From payments recorded in the margins of the same codex, we know that Jean received room and board at the Collège for extended periods in 1336, 1337, and apparently also in other years during the 1330s.[4]

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[1] See José Chabás and Bernard R. Goldstein, 'John of Murs Revisited: The *Kalendarium Solis et Lune* for 1321', *Journal for the History of Astronomy* 43 (2012), 411-37, at 412, here citing MS Brussels, Bibliothèque Royale, 1086-1115, fol. 26r.

[2] For the *Musica speculativa*, see MS Oxford, Bodleian Library, Bodley 77, fol. 99va: 'Explicit musica Boeci abbreviata a magistro Johanne de Muris anno domini 1323 mense Iunii Parisius in Sarbonna'. A similar colophon appears in MS Sankt Paul im Lavanttal, Stiftsbibliothek, 264/4, fol. 49r. For the *Arbor Boethii*, see MS Paris, Bibliothèque nationale de France, lat. 16621, fol. 64r, and Matthieu Husson, 'Les premier témoins de l'*Arbor boecii* de Jean de Murs: deux contextes distincts pour l'enseignement de l'arithmétique spéculative à Paris au quatorzième siècle', in *Mélanges en l'honneur de Danielle Jacquart* (Geneva, forthcoming).

[3] Lawrence Gushee, 'New Sources for the Biography of Johannes de Muris', *Journal of the American Musicological Society* 22 (1969), 3-26, at 16, here citing MS El Escorial, Real Biblioteca de San Lorenzo, O.II.10, fol. 162v.

[4] Gushee, 'New Sources', 15-18.

Little to nothing is known about the purpose and background of these various stays, although it makes sense to follow Lawrence Gushee in supposing that Jean continued to be drawn to the institution by its library.[5] By 1338 the Collège's *magna* and *parva libraria* together held well over 1400 books (not counting lost or absent volumes), among them several dozen volumes on mathematics and mathematical astronomy.[6] The potential role of the Sorbonne as a research library for astronomers may provide us with some, admittedly paper-thin, context for the work to be discussed in this article, which bears witness to the last of Jean des Murs's attested visits to the Collège: a brief set of *Canones tabularum Alfonsii* identifiable by their opening words *Prima tabula docet differentiam unius ere super aliam*. These *Canones* survive in two versions—one long, one short—in at least five different manuscripts, but have never received serious scrutiny. The following pages are an attempt to shed some light on this little-known text, which, despite its largely didactic nature, is not without revealing details. After some remarks on its manuscript transmission and a basic outline of its contents, I shall focus on three topics that are characteristic of Jean's interests as an astronomer: the length of the solar year, the calculation of syzygies, and the prediction of eclipses.

[5] Ibid., 17. The possibility that Jean was a *socius sine bursis* is explored in Laure Miolo's contribution to this volume.

[6] For the 1338 holdings, see Léopold Delisle, *Cabinet des manuscrits de la Bibliothèque nationale*, vol. 3 (Paris, 1870), 9-114. Further relevant details may now be gleaned from Claire Angotti, Gilbert Fournier, and Donatella Nebbiai, eds., *Les livres des maîtres de Sorbonne: histoire et rayonnement du collège et de ses bibliothèques du XIII*[e] *siècle à la Renaissance* (Paris, 2017). For the books annotated by Jean des Murs, see the Laure Miolo's article in this volume.

Manuscript witnesses

The extant copies of the *Canones tabularum Alfonsii* have all been mentioned before in the literature, albeit never together in one place.[7] I shall refer to them by the following sigla:

B	Oxford, Bodleian Library, Bodley 491, fols. 32r-33v
D	Oxford, Bodleian Library, Digby 97, fols. 122r-25r
E	Erfurt, Universitäts- und Forschungsbibliothek, Amplon. Q. 366, fol. 52r-v
H	Oxford, Hertford College, 4, fols. 140r-47r
P	Paris, Bibliothèque nationale de France, lat. 18504, fol. 209r-v

The most important of these witnesses is manuscript *H*, copied in England in the mid-fifteenth century, which is the only one to preserve the complete text of the 'long version' of Jean's *Canones* (ca. 7,000 words). It begins on fol. 140r with the heading *Canones tabularum Alfoncii*, *compositi Parisius in Sorbona*, and continues for 17 pages across three different explicits found on fols. 141Br (*Explicit deo gracias*), 142v (*Expliciunt canones tabularum illustris regis Alfoncii, compositi Parisius in Serbona* [!] *in domo scolarum*), 146v (*Explicit ars brevis de equacione eclipsis solis*), before finally ending on fol. 147r with the following

[7] See e.g. John D. North, 'The Alfonsine Tables in England', in *ΠΡΙΣΜΑΤΑ: Naturwissenschaftsgeschichtliche Studien*, eds. Y. Maeyama and W. G. Saltzer (Wiesbaden, 1977), 269-301, at 297; Emmanuel Poulle, 'John of Lignères', in *Complete Dictionary of Scientific Biography*, 27 vols. (Detroit, 2008), 7:128-33, at 133; Max Lejbowicz, 'Présentation de Jean de Murs, "observateur et calculateur sagace et laborieux"', in *Méthodes et statut des sciences à la fin du Moyen-Âge*, ed. Christophe Grellard (Villeneuve d'Ascq, 2004), 159-80, at 178; Emmanuel Poulle, 'Les astronomes parisiens au XIV^e siècle et l'astronomie alphonsine', in *Histoire littéraire de la France*, vol. 43.1 (Paris, 2005), 1-54, at 30. No credence should be given to the list in Ulrich Michels, *Die Musiktraktate des Johannes de Muris* (Wiesbaden, 1970), 10 (n. 36), which gives incorrect folio-numbers for *E* and *H* and includes several further manuscripts, none of which contain our text.

colophon: *Has canones composuit M<agister> Io<hannes> de Muris, Parisius in Sorbona, 1339*. This manuscript was still unknown to Pierre Duhem, who instead referenced *D*, another fifteenth-century English manuscript, for containing ‘des canons pour le calcul des éclipses’.[8] *D* in fact only contains the final third of the text found in *H*, most of which is devoted to eclipse calculations. It begins abruptly with a section headed (in both *H* and *D*) *Sermo de anni quantitate* and concludes on fol. 125r with a similar colophon: *Hos autem canones disposuit Iohannes de Muris Parisius in anno domini 1339*^{o} *in domo scolarium de Sorbonna*. The text exhibits a relatively low frequency of variations compared to *H* and even preserves the third of the three ‘internal’ explicits recorded in the latter (on fol. 124v).

The first scholar to confront the *Canones* in both these manuscripts was Lynn Thorndike,[9] who correctly discerned that the *Explicits* contained in *H* do not terminate the text and that the year 1339 mentioned in the colophon applies to all of its parts, ‘since in the opening description of the seven tables the year 1338 is mentioned in two examples’.[10] As a matter of fact, the number 1338 mentioned in this opening description (*H*, fols. 140r-140Ar) and elsewhere in the text (*H*, fol. 141Bv) consistently refers to completed years, such that the year in question is 1339. This includes the use of the date 2 May 1339 (expressed as 1338

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[8] Pierre Duhem, *Le système du monde: histoire des doctrines cosmologiques de Platon à Copernic*, 10 vols. (Paris, 1913-1959), 4:35. Duhem owed the reference to Antonio Favaro, ‘Intorno alla vita ed alle opera di Prosdocimo de’ Beldomandi matematico padovano del secolo XV (*fine*)’, *Bulletino di bibliografia e di storia delle scienze matematiche e fisiche* 17 (1879), 203-51, at 231. Duhem’s characterization of the text in *D* is at the basis of the misleading remarks in Michels, *Die Musiktraktate*, 9-10, and Olga Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, 9 vols. (Turnhout, 1994-2012), 5:124-31, at 126, where ‘*Canones de eclipsi lune* (1339)’ in *D* (fols. 124v-5r) are recorded separately from ‘*Canones tabularum Alphonsi* (1339)’ in *E* and *H*.

[9] Lynn Thorndike, *A History of Magic and Experimental Science*, 8 vols. (New York, 1923-1958), 3:301-303.

[10] Ibid., 3:303.

years, 4 months, 1 day) in a worked example illustrating a table for the conversion of calendrical dates into sexagesimal sums of days.[11]

Such references to the current year are completely absent from the much briefer version of the *Canones* attested in the three remaining manuscripts, *BEP*, which only goes up to the first explicit in *H* (fol. 141Br). The copy in *E* appears to date from the mid-fourteenth century, making it the earliest among the five preserved witnessed. The *Canones* here fit onto a single leaf (fol. 52) whose heading and colophon are silent on the work's date, although they do confirm Jean des Murs's authorship. On fol. 52r, we read: *Canones tabularum Alfoncii per magistrum Io<hannem> de Muris editi*. The colophon on the bottom of fol. 52v is more specific. It mentions a time difference of 48 minutes (equivalent to 12°) between Toledo and Paris, which Jean des Murs can be found employing in the 'long version' of the *Canones*, but also in other works from his pen: *Expliciunt canones tabularum Alfoncii ad meridiem Toleti, distantis a Parysius in occidente spatio 48 minutorum unius hore, editi a magistro Iohanne de Muris*.[12]

[11] *H*, fol. 140r: 'Exemplum: sunt anni Christi 1338, menses 4, dies una, quos extrahere pro 60^{mas} scire cupis.'

[12] Compare the 'long version' in *H*, fol. 144v: 'Cui adde 48 minuta hore, ut experientia nos docuit, una cum equacione dierum et eadem vera coniuncio diebus equatis Parisius patefiet.' Jean des Murs employs the same interval in his *Patefit*, as found in MS London, British Library, Royal 12.C.XVII, fols. 145v-210r, at fols. 168r, 205va, and in the astronomical tables discussed in José Chabás and Bernard R. Goldstein, 'John of Murs's Tables of 1321', *Journal for the History of Astronomy* 40 (2009), 297-320, at 299. By contrast, in his *Expositio intentionis regis Alfonsii circa tabulas ejus* (1321) he still speaks of an interval of 1;6h (16;30°). See Emmanuel Poulle, 'Jean de Murs et les Tables Alphonsines', *Archives d'histoire doctrinale et littéraire du Moyen Âge* 47 (1980), 241-71, at 266-7. Other attestations of the standard interval of 0;48h are recorded in Richard L. Kremer and Jerzy Dobrzycki, 'Alfonsine Meridians: Tradition versus Experience in Astronomical Practice *c.* 1500', *Journal for the History of Astronomy* 29 (1998), 187-99, at 194.

E's remark about the meridian of Paris reappears in the heading of *B*, which omits any mention of Jean des Murs: *Canones supra tabulas Alfonsi principis illustris Regis Castelle compositas ad meridiem Tholeti, que distat a Parisius in occidente spacio 48 minutorum unius hore* (fol. 32r). This late-fourteenth century manuscript from England covers the same portions of the text as *E* but adds to them several further paragraphs that are extraneous to Jean des Murs's work. Most of this material is devoted to sexagesimal fractions and proportions, a topic otherwise covered in Jean's *Tabula tabularum* and the accompanying canons.[13] The added material in *B* concludes with an *Explicit* on fol. 35r, after which the same scribal hand proceeds with a second user's manual for the Alfonsine Tables (fols. 35r-40v) as well as the tables themselves (fols. 41r-60r).

Another witness from the later fourteenth century is *P*, where the text opens as follows: *Incipiunt canones I<ohannis> de Muris super tabulas regis Alphunsi* [sic] *in astronomia* (fol. 209r). This copy lacks an explicit, as the text breaks off abruptly at the end of a passage dealing with the Sun's true longitude, leaving several empty lines on the page.

Structure and content

The 'long version' of the *Canones* attested in *DH* comes divided into three distinct parts. In the 'short version' transmitted in *BEP* there is no trace of the third of these parts, while the first part omits all of the worked examples for the year 1339. This may simply be a sign that the long version was edited down by some later redactor, but it cannot be excluded that *BEP* preserve an undated core version of the text that Jean des Murs decided to expand into a longer version during his stay at the Collège de Sorbonne in 1339. Whichever of these two

[13] Matthieu Husson, 'La *Tabula tabularum* de Jean de Murs et les modèles de l'arithmétique médiévale', *Cahiers de recherches médiévales et humanistes* 27 (2014), 97-122.

scenarios may have been the case, the following remarks proceed on the assumption that the long version is an authentic work by Jean des Murs. Some idea of the topics covered in each of its three parts may be obtained from the table of contents below.

I. Chronological tables

1. Table for intervals between epochs
2. Table for converting bissextile years and months into days
3. Table for converting non-bissextile years and months into days
4. Table for converting lunar years and months into days
5. Table for converting one era into another
6. Table for the initial weekdays of years and months
7. Table for converting sexagesimal minutes of hours and days

II. Planetary motions

8. Table for epoch values (*radices*)
9. Excess of revolution (I)
10. General instructions for mean motions
11. True motions

III. Miscellaneous / Special issues

12. Excess of revolution (II)
13. Mean syzygy (luminaries)
14. Planetary visibility
15. Planetary velocities
16. Planetary conjunctions

17. Sexagesimal reckoning / On the format of the Alfonsine Tables

18. On the length of the tropical year (*Sermo de anni quantitate*)

19. Sine and versine calculation

20. True syzygy (luminaries)

21. Solar eclipses

22. Lunar eclipses

Of the three main parts just noted, only parts (i) and (ii) follow the overall sequence of topics suggested by the Latin Alfonsine Tables, as represented by the *editio princeps* of 1483 and the modern edition published by Emmanuel Poulle, who concluded that the scope of these tables was originally limited to chronology, mean motions, and equations.[14] Part (i) is concerned with the chronological tables for eras and calendrical conversions that are normally found at the beginning a given set of Alfonsine Tables. Of the seven tables discussed in this part, table 1 was there to list time intervals between the epochs of the various eras to which the planetary mean-motion tables could be adapted. While the corresponding table in the *editio princeps* displays these intervals only in a sexagesimal format (where *7.21.40.38* in the first line is equivalent to 1,590,038 days), Jean des Murs evidently worked with a table that offered additional columns showing an equivalent number of days in the decimal place-value system as well as the corresponding number of years,

[14] See *Alfontii regis castelle illustrissimi celestium motuum tabule necnon stellarum fixarum longitudines ac latitudines Alfontii tempore ad motus veritatem mira diligentia reducte* (Venice, 1483), hereafter cited as *editio princeps*; Emmanuel Poulle, *Les Tables Alphonsines avec les canons de Jean de Saxe: édition, traduction et commentaire* (Paris, 1984). On the limited scope of the Latin Alfonsine Tables, see also Poulle, 'Y a-t-il du nouveau sur les tables alphonsines?', *Archives internationales d'histoire des sciences* 34 (2004), 141-55, at 144-46; Poulle, 'Les astronomes parisiens', 2-4.

months, days, and sexagesimal minutes of the day—a mode of presentation used in the Alfonsine Tables of manuscript *B*.

The connection between the tables in *B* and the *Canones* that precede them on fols. 32r-33v is strengthened by the way the chronological tables (fols. 41r-43v) and the tables for *radices* and the excess of revolution (fols. 44r-45r) come with sequentially numbered headings, from *Prima tabula* to *Nona tabula*. Jean des Murs uses the same ordinal numbers in part (i) and at the start of part (ii) of his *Canones*, stopping with the tables for the excess of revolution.[15] The remainder of part (ii) consists of some very concise explanations of the basic operations needed to extract mean and true longitudes of the Sun, Moon, and five planets. These explanations refer to the Alfonsine Tables for mean motions and equations in a general fashion, without describing each individual table.[16] It seems worth noting that Jean des Murs's description of the tables for planetary equations refers to headings (*tituli*) that were supposed to indicate whether the equations of centre and anomaly must be added or subtracted.[17] Such *tituli* are absent from the equation tables in the *editio princeps*, but they do appear—as instructions *minuatur* and *addatur*—in the version included in manuscript *B* (fols. 51v-60r).

The most obvious point of comparison for the first two parts of Jean's *Canones* is provided by John of Saxony's 'Alfonsine' canons of 1327, which survive in a vastly greater

[15] *H*, fol. 141Ar: 'Nona tabula est de revolucione ascendentis alicuius anni noti, que tabula supponit unam radicem introitus esse notam in tempore et loco.'

[16] In *H*, part (ii) is demarcated by a separate heading: 'Incipit secunda pars de motibus planetarum' (f. 141Ar).

[17] *H*, fol. 141Br: 'Compares ergo equationem centri et argumenti penes eorum titulos quos notasti et quid de illis equationibus sit agendum tituli te docebunt. Nam si utraque addenda vel minuenda fuerit, illud age. Si una sic, alia non, excessum maioris super minorem adde vel minue medio motui planete prout titulus te deducet et exibit verus locus syderis quesitus.'

number of manuscripts.[18] Similar to the long version of Jean's *Canones*, the canons composed by John of Saxony (Johannes Danck or Danekow) offer some worked examples for a date in the current year (here: 3 July 1327), but they are considerably more detailed and follow a different sequence of topics. Jean's *Canones*, by contrast, are characterized by their extreme concision,[19] but also by an artificial style that strives to avoid any repetitions in the description of mathematical operations. For a newcomer to the field, the 1327 canons would have been the preferred choice, whereas the 1339 canons by Jean des Murs may have been aimed at a more experienced audience, who were already familiar with some of the basic moves involved in astronomical computation and the terminology involved, and who merely looked for some quick reminders concerning the details of particular operations.

The lion's share of Jean des Murs's *Canones*, roughly two thirds of the entire text, is taken up by part (iii), which is present only in *D* (partially) and *H* (completely). It mentions several additional tables that cannot be found among those included in *B* or in the core version of the Alfonsine Tables reconstructed by Poulle, while most of them are also absent from the 1483 *editio princeps*. These additional tables are concerned with (a) planetary

[18] The text was printed with a French translation in Poulle, *Les Tables Alphonsines*, 30-105.

[19] Emmanuel Poulle, 'Les *Tables Alphonsines* sont-elles d'Alphonse X?', in *De astronomia Alphonsi regis*, eds. Mercè Comes, Roser Puig, and Julio Samsó (Barcelona, 1987), 51-69, at 56, already emphasized the 'remarquable économie de langage' of Jean's canons.

visibility;[20] (b) the daily unequal motion of the planets;[21] (c) sine calculation;[22] (d) the equation of time;[23] (e) parallax;[24] (f) solar eclipses.[25] There are no indications in his text that Jean des Murs regarded any of these tables as attributable to King Alfonso or belonging to the corpus of tables elaborated by astronomers at his court. Instead, it would appear that he included part (iii) specifically to cover aspects of computational astronomy that fell outside the scope of the Alfonsine Tables as he knew them, which focused narrowly on chronology, mean motions, and equations.

Of the six items just mentioned, (e) and (f) come into play in the lengthiest sub-section of Jean des Murs's *Canones*, which is entirely devoted to the times, magnitudes, and durations of solar eclipses. That this was a topic of long-standing interest to our author is evident from the various tables contained in Jean's *Patefit* (see below), but also from some of

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[20] *H*, fol. 142r. The tables described here correspond to types OA11 and OA12 edited in Fritz S. Pedersen, *The Toledan Tables: A Review of the Manuscripts and the Textual Versions with an Edition*, 4 vols. (Copenhagen, 2002), 4:1530-37. See also José Chabás and Bernard R. Goldstein, *A Survey of European Astronomical Tables in the Late Middle Ages* (Leiden, 2012), 124-26.

[21] *H*, fol. 142v. See Bernard R. Goldstein, José Chabás, and José Luis Mancha, 'Planetary and Lunar Velocities in the Castilian Alfonsine Tables', *Proceedings of the American Philosophical Society* 138 (1994), 61-95; Pedersen, *The Toledan Tables*, 2:1433-36; José Chabás and Bernard R. Goldstein, *The Alfonsine Tables of Toledo* (Dordrecht, 2003), 170-82; Chabás and Goldstein, *A Survey*, 99-100.

[22] *H*, fol. 144r.

[23] *H*, fol. 144v. Cf. the *editio princeps*, sigs. kr–k2r, where the equation of time is part of a table for right ascension. See also Pedersen, *The Toledan Tables*, 3:968-76; Chabás and Goldstein, *A Survey*, 28.

[24] *H*, fols. 144v-5r. Cf. the *editio princeps*, sigs. l5r–l8v; Pedersen, *The Toledan Tables*, 4:1380-1404, 1437-42; Chabás and Goldstein, *A Survey*, 131-35.

[25] *H*, fol. 146v. Cf. the *editio princeps*, sig. m1r-v; Pedersen, *The Toledan Tables*, 4:1458-71; Chabás and Goldstein, *A Survey*, 168-69, 172-74.

the autograph notes that adorn the aforementioned Escorial codex.[26] Another issue foregrounded in Jean des Murs's writings, in particular in his earlier *Expositio* of the Alfonsine Tables (1321), is the precise length of the tropical year. In the *Canones* this topic is present in the guise of a brief *Sermo de quantitate anni*, which is offset from the rest of the text by a special heading.

In what follows, I shall dig somewhat deeper into part (iii) by presenting three case studies that revolve around the astronomical topics just mentioned. After a closer look at Jean's *Sermo* on the length of the year, I shall spend the last two portions of this article on Jean's approaches to calculating the time and circumstances of eclipses. The first of these will focus on a crucial preliminary step in any eclipse calculation, which is to determine the time interval from mean to true syzygy. The second will deal with eclipse magnitudes and the parallax-correction needed to find the time of mid-eclipse. As we shall see at the end of this article, Jean's treatment of these issues in the *Canones* was strongly dependent on a little-known work by John of Genoa written in 1332.

Jean des Murs on the length of the tropical year (*Sermo de quantitate anni*)

[26] On these annotations, see Gushee, 'New Sources', 14-16; Guy Beaujouan, 'Observations et calculs astronomiques de Jean de Murs (1321-1344)', in *Proceedings of the XIVth International Congress of the History of Science*, 4 vols. (Tokyo, 1974), 2:27-30, repr. as chapter 7 in Beaujouan, *Par raison des nombres: l'art du calcul et les savoirs scientifiques médiévaux* (Aldershot, 1991); Matthieu Husson, 'Exploring the Temporality of Complex Computational Practice: Two Eclipse Notes by John of Murs in the ms Escorial O II 10', *Centaurus* 58 (2016), 46-65.

The section with the title *Sermo de quantitate anni* appears midway into part (iii) of Jean's *Canones*, at the very beginning of the fragment preserved in *D*. It is both brief and interesting enough to be quoted in its entirety:

> The Alfonsists [i.e., the makers of the Alfonsine Tables] said that the length of the year is 365 days, 5 hours, 49 minutes, 15 seconds, 59 thirds, 34 fourths, 3 fifths. This much is apparent from the tables for the revolutions of years, if it is they [i.e., the Alfonsists] who made them. It should follow that if you divide the zodiac [i.e., 360°] by this [value], the result will be the daily motion of the Sun. But this is not so. Instead you will see the Sun moving beyond [360° in this period of time]. It follows that the length of the year has not been inscribed [into the tables] with full precision or that the daily motion of the Sun has not been truthfully tabulated. Yet since I do not have any basis for casting suspicion on the daily [motion] of the Sun, it is the aforementioned length of the year that is suspect. I therefore corrected it in this manner: I divided the zodiac by the daily motion of the Sun that is inscribed in the tables and the following length of the year came out: 365 days, 5 hours, 49 minutes, 15 seconds, 58 thirds, 49 fourths, 46 fifths. The difference between these [lengths] is small, but it is disgraceful to remain ignorant even in very small things. Now, the length of the year that has been corrected in this way is called the 'mean' [length], seeing as the mean motions of the planets are tabulated in relation to it and it is the one they [i.e., the Alfonsine mean motion tables] assume to be the annual period of revolution. It is nevertheless not like this, but because of the motion of the eighth sphere and the variable motion of the apogee of the Sun and the change in the [solar]

> equation it is instead necessary to put down individual years as unequal to each other.[27]

Most of this passage addresses an apparent internal contradiction in the Alfonsine Tables, whose standard table for the Sun's mean motion operates with a daily increase of 0;59,8,19,37,19,13,56°/d.[28] This parameter fails to mesh with the values for the length of the tropical year that are given in the tables for the monthly and annual excess of revolution.[29] In the second of these tables entries are supposed to represent the accumulating difference between a Julian year of 365d and the Alfonsine length of a tropical year, which difference could be used to cast anniversary horoscopes or to facilitate finding the time of the vernal equinox from one year to the next.[30] In the *editio princeps* of the Alfonsine Tables, the tabulated excess is shown as 20;25,14,34h after 20 years, which suggests an annual difference of (1d - 20;25,14,34h) ÷ 20 = 0;10,44,16,18h. The following entries for 40, 60, 80, 100, 200

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[27] *H*, fols. 143v-44r: 'Dixerunt Alfonsiste, sicut patet in tabulis de annorum revolutionibus, si fecerunt, anni quantitatem esse 365 dies, 5 hore, 49 minuta, 15 secunda, 59 tertia, 34 quarta, 3 quinta. Ergo, si per hanc zodiacum diviseris motus solis diurnus exibit. Sed non est sic, ymmo solem ultra transire videbis. Ergo non est precisa anni quantitas assignata aut motus solis diurnus non est veraciter tabulatus. Sed cum non habeam unde possim diurnum solis reddere suspectum, ideo predicta anni quantitas est suspecta. Hanc ergo sic correxi: divisi zodiacum per motum solis diurnum in tabulis assignatum et exivit anni quantitas talis: 365 dies, 5 hore, 49 minuta, 15 secunda, 58 tertia, 49 quarta, 46 quinta. Inter quas est pauca differentia, sed turpe est in minimis ignorare. Hec autem anni quantitas sic correcta 'media' nuncupatur, eo quod ad eam sunt planetarum medii motus tabulati et eam supponunt anni revolutionem. Non tamen est ita, sed neccessarium est propter motum octavi circuli et varium motum augis solis mutationemque equacionis annos ponere singulos inequales.' The parallel text in *D*, fol. 122r, does not differ in any significant way.

[28] Poulle, *Les Tables Alphonsines*, 134.

[29] Ibid., 130. See also Pedersen, *The Toledan Tables*, 4:1589.

[30] Chabás and Goldstein, *A Survey*, 218-20.

... 800 years are exact multiples of this value, confirming that the table operates with a tropical year length of 365;15d - 0;10,44,16,18h = 365d 5;49,15,43,42h.

A different story is told by the *Tabula revolutionis mensium,* which breaks the tropical year down into 13 incremental steps of 28d 2;17,38,9,11,51h.[31] The final entry is 365d 5;49,15,59,34,3h, the precise value Jean des Murs mentions at the beginning of his *Sermo de quantitate anni*.[32] If this were the actual length of the tropical year presupposed in the Alfonsine Tables, the Sun would return to the same point on the zodiac after the stated number of days, hours, and fractions of time. Yet, as Jean reminds us, 'this is not so'. Once the solar mean motion of 0;59,8,19,37,19,13,56°/d is multiplied by the stated 365d 5;49,15,59,34,3h, it turns out that the Sun covers not 360° but 0;59,8,19,37,19,13,56°/d × 365d 5;49,15,59,34,3h = 360;0,0,0,1,49,6,5,13...°. There are two possible explanations for this discrepancy: (i) the length of the year indicated by the tables for the excess of revolution is incorrect or (ii) the daily mean motion of the Sun is wrongly tabulated. Jean states that he sees no reason to doubt the accuracy of the mean motion parameter, so he suspects the error to lie in the table for the excess of revolution (*Sed cum non habeam unde possim diurnum solis reddere suspectum, ideo predicta anni quantitas est suspecta*). His reasoning here is not obvious, but it may be that he regarded the Sun's mean motion as fundamental to the system as a whole and hence more basic than the excess of revolution. In order to obtain the 'correct'

[31] This type of table is discussed in Bernard R. Goldstein and José Chabás, 'Planetary Velocities and the Astrological Month', *Journal for the History of Astronomy* 44 (2013), 465-78. See also Chabás and Goldstein, *A Survey*, 221-3.

[32] The contradiction between tables for the *Revolutio mensium* and the *Revolutio annorum* is not one Jean des Murs addresses in his known works. A possible reaction to it appears in *B*, fol. 45r, which simplifies the *Revolutiones annorum* by operating throughout with a tropical year of 365d 5;49,16h and hence with a rounded version of 365d 5;49,15,59,34,3h.

length of the tropical year, Jean divides 360° by the mean daily motion, yielding 360° ÷ 0;59,8,19,37,19,13,56°/d = 365d 5;49,15,58,49,46h.

It is worth comparing the very concise discussion of this issue in the *Sermo de quantitate anni* with the more longwinded and less well-ordered remarks Jean had jotted down 18 years earlier as part of his *Expositio intentionis regis Alfonsii circa tabulas ejus*. Jean here begins his attempted reconstruction of the rationale behind the Alfonsine Tables by citing their year length as 365;14,33,9,59,20,7,30d. If the fractional excess in this value is converted from days into hours, one obtains 365d 5;49,15,59,44,3h, which differs from the aforementioned 365d 5;49,15,59,34,3h only in the fourth and penultimate sexagesimal-fractional place. If the cited 365;14,33,9,59,20,7,30d were accepted as the period it takes the Sun to complete 360°, the corresponding daily mean motion would have to be 0;59,8,19,37,18,51,57,46...°/d instead of the 0;59,8,19,37,19,13,56°/d postulated by the Alfonsine Tables. Jean expresses the same problem by spelling out the excess beyond 360° that would result from multiplying the Alfonsine mean-motion parameter by 365;14,33,9,59,20,7,30d. In the only preserved copy of the *Expositio*, the result of this operation is written as 0;0,0,0,2,13,45,34,27,39,42,49,59,32,7°,[33] whereas a computation with the values at hand would yield 365;14,33,9,59,20,7,30d × 0;59,8,19,37,19,13,56°/d = 360° + 0;0,0,0,2,13,44,33,23,41,40,36,54,30°.

After a number of further calculations, some of them redundant, Jean returns to the subject of the solar year in the final section of his *Expositio*, which concerns the times of the Sun’s entry into the first degrees of Aries, Cancer, Libra, and Capricorn. Using the year 1301 as his example, Jean tells us that he arrived at the conclusion that the times of ‘certain entries have variable differences in relation to each other, now greater, now lesser, whereas others do

[33] See the edition of Jean’s text in Poulle, ‘Jean de Murs’, 251.

not vary, but have perpetually the same difference'.[34] According to the view put forward at the end of the *Expositio*, the interval between one equinox or solstice and the immediately following or preceding one—and hence the lengths of the individual astronomical seasons—will be variable (*mutabilis*), a variation Jean des Murs puts down to the 'motion of the apogee of the Sun, which is continuous, but not uniform'. By contrast, intervals from equinox to equinox, or from solstice to solstice, supposedly remain constant due to the constant eccentricity of the underlying model, meaning that the distance between the centre of the deferent and the centre of the world does not change over time.[35]

If we can trust the text as preserved in the only known manuscript,[36] Jean here effectively conflated two similar-sounding, but fundamentally different propositions. One follows from the stable eccentricity of the Alfonsine solar model, which entails that the Alfonsine Sun always takes the same time to return to the points where its circular path intersects with the line of apsides (i.e., the line connecting the apogee with the perigee), namely one-half of a mean tropical year of 365d 5;49,15,58,49,46h. The other is the (incorrect) notion that the half-years measured from a given equinox or solstice will always stay the same. What made the latter sort of constancy impossible from an Alfonsine perspective was the variable motion of the solar apogee, which was subject to both linear precession and a periodic 'access and recess'.[37] If the longitudinal increase of the apogee was

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[34] Ibid., 267: 'Et inde percepi quod quidam introitus habent inter se differentias mutabiles, nunc majores nunc minores, alii invariabiles sed in eadem differentia sempiterna.'

[35] Ibid., 268: 'In hiis autem mutatio est propter motum augis solis continuum sed non uniformem, immutatio autem provenit propter centrorum scilicet deferentis et mundi distanciam immutabilem et perhennem.'

[36] MS Paris, Bibliothèque nationale de France, lat. 7281, fols. 156v-60r.

[37] Chabás and Goldstein, *The Alfonsine Tables of Toledo*, 256-66. See also C. Philipp E. Nothaft, 'Criticism of Trepidation Models and Advocacy of Uniform Precession in Medieval Latin Astronomy', *Archive for History of Exact Sciences* 71 (2017), 211-44, at 227-35, with further references.

hence ‘continuous, but not uniform’, the same necessarily applied to the increase of the value of the solar equation at 0° or 180° tropical longitude, in which case variability was not at all restricted to the astronomical seasons, as Jean seems to have thought in 1321. Instead, one had to treat the year length implied by the Alfonsine parameter for the mean solar motion as a *mean* value and carefully distinguish it from the *true* tropical year (here understood as the interval between two moments of 0° true longitude), whose length was subject to variation, albeit on an extremely subtle and practically imperceptible level.

While this consequence remains unacknowledged in Jean’s *Expositio*, he had clearly caught on to it by the time he wrote the *Canones*. This much is obvious from his disclaimer that the ‘correct’ tropical year of 365d 5;49,15,58,49,46h he had extracted was no more than a *quantitas media*. The true length of the tropical year, by contrast, was bound to change, ‘because of the motion of the eighth sphere and the variable motion of the apogee of the Sun and the change in the [solar] equation’.[38] This explanation, which is entirely sound, reveals to us the increased understanding of the subject matter Jean des Murs had gained between 1321, when he made his first attempt to explicate the models and rationale underlying the Alfonsine Tables, and 1339, when he sat down to pen a new user’s manual for them. As far as I am aware, the *Canones tabularum Alfonsii* are the earliest preserved text to draw attention to the variability of the true solar year in the Alfonsine model. Jean’s realization of this esoteric fact, a fact barely ever mentioned in modern studies on Alfonsine astronomy, was of sufficient interest still to be quoted 75 years later, in Pierre d’Ailly’s astrological *Elucidarium* of 1414.[39] It is the only citation of the *Canones* in a later text to have been identified so far.

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[38] See n. 27 above.

[39] See Pierre d’Ailly, *Elucidarium astronomice concordie cum theologica et hystorica veritate,* ch. 37, in *Tractatus de imagine mundi et varia ejusdem auctoris et Joannis Gersonis opuscula* (Leuven, *c.*1480/83), sig. gg5r, with attribution of the cited passage to *Joannes de Muris*.

From mean to true syzygy

The interval between mean and true syzygy (hereafter: *Δt*) was one of the trickiest and most widely discussed computational problems in medieval astronomy. That Jean des Murs played an innovative role in contemporary efforts to solve it in a convenient and user-friendly manner has been highlighted most clearly by Richard L. Kremer in his analysis of the *Tabula vere coniunctionis et oppositionis solis et lune*, which is one of the many tables for the Sun and Moon contained in Jean des Murs's *Patefit*.[40] From the earliest known copy of this voluminous work, now MS London, British Library, Royal 12.C.XVII, fols. 144r-218v (hereafter: *L*), it appears that the *Patefit* was produced between 1329 and 1335 for the monastery of Lec Bec-Hellouin and its abbot Geoffroy Faé.[41] A *terminus post quem* for its London copy is provided by the subjoined *Canones eclipsium* by the contemporary astronomer John of Genoa (fols. 214ra-17ra), which come with a colophon dating the completion of the text to 22 January 1332. As we shall see below, this work had a significant influence on the *Canones* Jean des Murs was to write seven years later, in 1339.

Apart from including the aforementioned *Tabula vere coniunctionis et oppositionis solis et lune*, Jean's *Patefit* also offered some instructions on how to find *Δt* by direct computation, not without warning readers that these computations were going to be long-

[40] Richard L. Kremer, 'John of Murs, Wenzel Faber and the Computation of True Syzygy in the Fourteenth and Fifteenth Centuries', in *Mathematics Celestial and Terrestrial: Festschrift für Menso Folkerts zum 65. Geburtstag*, eds. Joseph W. Dauben, Stefan Kirschner, Andreas Kühne, Paul Kunitzsch, and Richard P. Lorch (Stuttgart, 2008), 147-60. See also Chabás and Goldstein, 'John of Murs's Tables of 1321', 314-16.

[41] See the remarks on this manuscript in C. Philipp E. Nothaft, 'John of Murs and the Treatise *Autores kalendarii* (1317): A Problem of Authorship', *Sudhoffs Archiv* 99 (2015), 209-29, at 227-28.

winded and confront them with ‘a great multitude of numbers. Nevertheless, it is a method free from any error’.[42] What Jean des Murs describes in the section that follows these remarks is on the whole very similar to the procedures recommended in other canons available at the time, such as those composed by his Parisian contemporaries Jean de Lignères (1322) and John of Saxony (1327),[43] who in turn partly relied on the standard canons to the old Toledan Tables.[44] One simple trick common to all of these sources concerns the parameter needed to extract the Moon’s hourly velocity from the relevant tables. Rather than entering the table in question with the mean lunar anomaly at the time of mean syzygy, the various canons recommend adjusting this value based on the true elongation between Sun and Moon at mean syzygy (η), which the sources usually refer to as the *longitudo* of either Sun or Moon. This ‘adjusted’ anomaly, α, stands in the following relation to the mean anomaly $\bar{\alpha}$:

$$\alpha = \bar{\alpha} - \frac{13}{24}\eta$$

One advantage of this procedure is that it makes it possible to obtain from the tables something close to an ‘average’ lunar velocity for the whole time interval separating mean from true syzygy.[45] Jean des Murs heeded the same principle when describing the calculation

[42] Jean des Murs, *Patefit*, pt. 2, MS *L*, fol. 208ra: ‘Nec volo sub silentio pertransire quin vera coniunctio et oppositio aliter habeatur, sed diffusius et cum pena et cum magna multitudine numerorum. Tamen est modus ab omni remotus errore.’

[43] For Jean de Lignères, see ch. 32 and 33 of the canons starting ‘Priores astrologi...’. I have used MS Paris, Bibliothèque nationale de France, lat. 7281, fols. 186v-201v, where the relevant sections appear on fols. 193r-94r. For John of Saxony, see ch. 22 of the canons edited and translated in Poulle, *Les Tables Alphonsines*, 80-87, and the discussion in Richard L. Kremer, ‘Thoughts on John of Saxony’s Method for Finding Times of True Syzygy’, *Historia Mathematica* 30 (2003), 263-77.

[44] See Pedersen, *The Toledan Tables*, 2:449–453 (Cb170-78).

[45] See on this point José Chabás and Bernard R. Goldstein, ‘Nicholaus de Heybech and His Table for Finding True Syzygy’, *Historia Mathematica* 19 (1992), 265-89, at 269.

of *Δt* in his *Patefit*, in which he carefully distinguished the mean anomaly at mean syzygy from the *argumentum lune equatum,* which is equivalent to *α*.[46] Apart from describing it theoretically in the *Patefit*, however, Jean des Murs also applied it practically, as can be seen from his handwritten notes on the annular solar eclipse of 14 May 1333. In predicting the time of this event, Jean adjusted the lunar anomaly in precisely the specified way, by increasing the *longitudo* by 1/12th and halving the result.[47] Having found *Δt*, he proceeded to determine the true longitudes of Sun and Moon at the time of true syzygy, for which purpose he employed another 'quick fix' that he had already recommended in his *Patefit*. It involved no more than de- or increasing the true solar longitude at the moment of mean conjunction by 1/12th of the *longitudo* and the corresponding true lunar longitude by the *longitudo* + 1/12th.[48] In more formal terms, the ways to get from the true solar longitude at mean syzygy, λ^*_s, to the true solar longitude at true syzygy, λ_s, and from the true lunar longitude at mean syzygy, λ^*_m, to the true lunar longitude at mean syzygy, λ_m, were supposed to look as follows:

$$\lambda_s = \lambda^*_s - \frac{1}{12}\eta$$

$$\lambda_m = \lambda^*_m - \frac{13}{12}\eta$$

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[46] MS *L*, fol. 208rb: 'Motus autem lune in una hora sic invenitur: longitudo cum sua 12ª in duo equa partire et unam medietatem adde argumento lune, si longitudo fuerit solis, vel deme, si lune. Et exibit argumentum lune equatum, cum quo intra tabulam equationis lune et in eius directo ponitur horarius lune motus.'

[47] See the calculations in the left-hand columns of MS El Escorial, Real Biblioteca de San Lorenzo, O.II.10, fol. 92v, which are partly reproduced in Husson, 'Two Eclipse Notes', 52, 56.

[48] MS *L*, fol. 208va: 'Insuper longitudinem cum sua 12ª adde loco lune vero tempore medie coniunctionis vel oppositionis, et 12ª tantum loco solis, si longitudo fuerit solis, vel deme, si lune, et exibit verus locus luminarium ad tempus vere coniunctionis vel oppositionis equalis in omnibus, aut errasti.' The assumption here is that the velocities of the Sun and Moon remain constant at a ratio of 1:13. For the relevant passage in the *Canones Azarchelis,* see Pedersen, *The Toledan Tables*, 2:452 (Cb174). The rule also appears in ch. 33 of Jean de Lignères's canons of 1322, as found in MS Paris, Bibliothèque nationale de France, lat. 7281, fol. 193v.

This approach was convenient in that it automatically led to identical longitudes at true syzygy—1s 1;16,46° in the case of Jean's computation for the conjunction of May 1333[49]—, but it was also considerably less precise than the sort of iterative procedure John of Saxony had laid out in some detail in his canons of 1327. According to the latter, the usual approach of dividing the true elongation (*longitudo*) at mean syzygy by the difference between the velocities of Sun and Moon (known as the *superlatio*) will only yield a first approximation to Δt, such that the resulting time of true syzygy t^* is correct to the nearest hour. In order to draw closer to the actual time of true syzygy, one must determine the true *longitudo* at the new time t^* and then compare it to the corresponding value at t^* + 0;1d, one sexagesimal minute of the day (= 0;24h) later. From this comparison, the calculator obtains the change in elongation over the course of a day-minute. The *longitudo* at t^* must be divided by this value to yield the remaining interval in minutes from t^* to the actual time of true syzygy.[50] Cumbersome as this approach may have been, it was also very reliable. Kremer has demonstrated that the procedure described in John of Saxony's canons of 1327 will provide estimated times of true syzygy that are within one hour-minute of the time when the true elongation implied by the planetary equations of the Alfonsine Tables reaches 0° or 180°.[51] By contrast, the initial result Jean des Murs managed to obtain in 1333 differed from the appropriate moment by approximately two hour-minutes. A calculation using nothing but the Alfonsine mean motions and equations would show that the true elongation between Sun and

[49] See El Escorial, Real Biblioteca de San Lorenzo, O.II.10, fol. 92v, where the longitudes of Sun and Moon at the time of mean conjunction are 1s 1;35,24° and 1s 5;19,4°, while $\frac{1}{12}\eta$ = 0;18;38° and $\frac{13}{12}\eta$ = 4;2,18°.

[50] See ch. 22 of the canons printed in Poulle, *Les Tables Alphonsines*, 84-86.

[51] Kremer, 'Thoughts', 268-71.

Moon reached 0° at 01:17:38h after noon on 14 May, whereas Jean's calculation in the Escorial codex places the corresponding moment at 01:19:50h.[52]

Signs that Jean recognized the limitations of his own method are in fact discernible on the same manuscript page, which offers an alternative calculation of Δt based on 'tables for mean motions, which are more precise' (*per tabulas de mediis motibus, que sunt precisiores*). Compared to the first batch of calculations, the true positions of Sun and Moon here change from 1s 1;16,46 to 1s 1;17,24°, which is in much better agreement with the result one would expect on the basis of the Alfonsine parameters (1s 1;17,28°). The same holds true for the stated time of true syzygy at the Toledan meridian, which is now shifted back by more than a minute, to 01:18:29h. This shift had the added benefit of getting Jean des Murs closer to the time he was able to derive by observing the eclipse himself. Based on his altitude measurements, Jean concluded that the eclipse in question had begun 02:20h after noon. Computations based on a true syzygy time of 01:19:50h had instead led him to place the corresponding moment at 2:37:16h after noon. With the reduced time of true syzygy afforded *per tabulas de mediis motibus* (01:18:29h), Jean was able to decrease the computed *initium eclipsis* to 02:23:46h after noon, making for a significantly better agreement with his observation.[53]

Although it does not explicitly say so in the Escorial codex, Jean's alternative method *per tabulas de mediis motibus* must have referred to some version of the iterative procedure John of Saxony had recommended in 1327. Rather than shifting the true longitudes of Sun and Moon based on their elongation at mean syzygy, Jean des Murs now used the Alfonsine mean motions and equations to compute the actual solar and lunar longitudes at t^* and took their remaining elongation as the basis for a second adjustment. That Jean des Murs used *per*

[52] MS El Escorial, Real Biblioteca de San Lorenzo, O.II.10, fol. 92v.

[53] Ibid. See on this point also Beaujouan, 'Observations', 28-29; Kremer, 'Thoughts', 271-72.

tabulas de mediis motibus in this technical sense becomes obvious from a look at his *Canones tabularum Alfonsii* of 1339, which confirm that Jean des Murs's experience with the eclipse of 1333 made him accept the iterative approach as the more reliable of the two options he had tried out in the Escorial codex. According to the *Canones* the initial result for the time of true conjunction had to be taken as the basis for a new calculation of the true longitude of Sun and Moon 'using the tables for their mean motions' (*per tabulas de mediis motibus eorundem*):

> And if the positions are similar down to the relevant fractions, you will acknowledge that you have the true conjunction. If they fall apart, do the same thing as before and do not stop until equal positions, which attest to the true conjunction of the luminaries, have been found through the main tables.[54]

Jean's instructions for finding Δt that precede this statement are largely congruent with those already provided in the *Patefit* some years earlier, although presented in a significantly abbreviated form, to the extent that the relevant section in the *Canones* encompasses of no more than 134 words.[55] One mark of this extreme concision on Jean's part is his failure to offer any instructions on to how to derive α from $\bar{\alpha}$ in the process of computing the hourly velocity of the Moon. All he tells us is that one must use the *argumentum equatum lune tempore medie coniunctionis*. From the vantage point of an uninitiated reader, this phrase might easily be misconstrued as referring to the true anomaly at the time of mean conjunction, whereas in the context of the method described here, *argumentum equatum*

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[54] *H*, fol. 144v: 'Ad illud tempus equa luminaria per tabulas de mediis motibus eorundem. Et si loca sint similia usque ad debitas fractiones, veram coniunctionem utique fateberis te habere. Si distent, iterum fac ut ante et non cesses donec per tabulas principales loca similia reperta sint, que coniunctionem veram luminarium attestantur.'

[55] See *H*, fol. 144r-v, which is to be compared with the text of the *Patefit* in *L*, fol. 208r.

refers to a correction applied to the mean anomaly in order to shift it to the approximate mid-point between mean and true syzygy. Hence, while the *Canones* improve upon the corresponding section in the *Patefit* by taking into account the lessons Jean had learned when calculating the solar eclipse of 1333, the simultaneous process of abbreviation and condensation gave rise to a text so taut that it can only have been of use to an expert-level reader, who instead of requiring a detailed step-by-step instruction would have been content with a few pointers to the essential components of a problem such as the interval from mean to true syzygy. Regardless of whether it can be considered a feature or a bug, the pauciloquent nature of Jean's *Canones* certainly goes a long way towards explaining their very limited diffusion during the fourteenth and fifteenth centuries.

Eclipse calculation: the influence of John of Genoa

In the context of the *Canones* of 1339, finding the time of true syzygy was the entry-level move in a much larger series of computational steps that were meant to provide users of the Alfonsine Tables with precise information about the time, location, magnitude, duration, and other circumstances that characterize an eclipse of the Sun or Moon. Jean des Murs was in fact just one of several astronomers active in Paris during the 1320s and 1330s who took an interest in these computational methods and authored brief texts to facilitate their use. One popular example are the canons on eclipses that appear at the tail end of John of Saxony's canons for the Alfonsine Tables in several manuscripts as well as in the fifteenth-century *editio princeps*.[56] Although these canons are sometimes dated to 1330 and do not appear to

[56] *Editio princeps*, sigs. b4r-b7v. See also the transcription of this edition in José Martínez Gázquez, ed., *Traducción castellana anónima de los Cánones de Juan de Sajonia: las tablas de los movimientos de los cuerpos çelestiales del Iluxtrisimo Rey don Alono de Castilla seguidas de su Additio* (Murcia, 1989), 95-129.

belong integrally to the Alfonsine canons of 1327, their common ascription to John of Saxony is likely to be reliable.[57] An early witness to this ascription is the aforementioned London codex (*L*) annotated by Jean des Murs, which closes with some excerpts that combine John of Saxony's canon on solar eclipses with further material on the calculation of true syzygy drawn from the main canons of 1327.[58] These excerpts are preceded by John of Genoa's *Canones eclipsium*, which are dated very precisely to 22 January 1332.[59] This little work of ca. 3,100 words survives in at least four other manuscripts, one of which is *D*, where it comes immediately after Jean des Murs's *Canones tabularum Alfonsii*.[60] There are several instances of close verbal and doctrinal convergence between these two texts, one of which is their respective set of instructions on how to derive the digits of a solar eclipse from the apparent diameters of the Sun and Moon.

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[57] See Poulle, *Les Tables Alphonsines*, 24.

[58] *L*, fol. 217rb: 'Ad habendum diversitatem aspectus lune pro situ in epiciclo Iohannes de Saxonia dicit sic'. Most of the following material deals with the parallax-correction involved in finding the mid-point of a solar eclipse.

[59] *L*, fols. 214ra-17ra. On John of Genoa (*Iohannes de Ianua*), see Duhem, *Le système*, 4:74-75; Lynn Thorndike, 'Notes on Some Astronomical, Astrological, and Mathematical Manuscripts of the Bibliothèque Nationale, Paris', *Journal of the Warburg and Courtauld Institutes*, 20 (1957), 112-72, at 116-17; Fritz S. Pedersen, 'Scriptum Johannis de Sicilia super canones Azarchelis de tabulis Toletanis', pt. 1, *Cahiers de l'Institut du Moyen-Âge Grec et Latin* 51 (1986), 1-128, at 17-18; Jean-Patrice Boudet, *Lire dans le ciel: la bibliothèque de Simon de Phares astrologue du XV^e^ siècle* (Brussels, 1994), 184-85; Chabás and Goldstein, *The Alfonsine Tables*, 289-90.

[60] *D*, fols. 125r-28v. Further copies appear in MSS Florence, Biblioteca Medicea Laurenziana, Ashburnham 206 (132), fols. 73r-76r; Paris, Bibliothèque nationale de France, lat. 7281, fols. 206r-208r; Paris, Bibliothèque nationale de France, lat. 7322, fols. 39va-41va.

John of Genoa:[61]	Jean des Murs:[62]
Deinde iunge ambas dyametros simul et collectum divide per medium, quod medium, si sit equale et minus latitudine lune visa tempore medie eclipsis, non erit eclipsis. Si autem sit maius, subtrahe minus a maiori. Residuum multiplica per 12 et productum divide per dyametrum solis reducto utroque ad easdem fractiones et proveniunt puncta eclipsis. Et si aliquid remanet, fac ut dictum est sepe prius.	*Ambas* ergo solis et lune *dyametros iunge simul collect*isque *medium*, *si sit equale* vel *minus latitudine lune visa tempore* coniunctionis visibilis, omnino *non erit eclipsis*. *Si autem maius*, eclipsis impossibile est non esse. Deme ergo minus de maiori et in 12 residuum duc productumque divide per solis dyametrum et puncta eclipsis provenient ea divisione qua dyameter solis scindatur in 12 sectiones.

This simple algorithm, although it is attested in several earlier texts,[63] did not represent the standard way in which late medieval astronomers determined eclipse magnitudes. Instead of bothering with the diameter of either luminary, it was *de rigeur* to take recourse to specially devised tables in which the digits and immersion of a solar or lunar eclipse could be found as

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[61] *L*, fol. 215vb.

[62] *H*, fol. 146r.

[63] See, for example, al-Battānī, *De scientia stellarum*, ch. 44, in *Continentur in hoc libro: Rudimenta astronomica Alfragani. Item Albategnius astronomus peritissimus de motu stellarum* etc. (Nuremberg, 1537), fol. 68r; *Almagesti minor*, bk. VI, ch. 18, MS Paris, Bibliothèque nationale de France, lat. 16657, fol. 130r, available at https://ptolemaeus.badw.de/ms/2/2/130r; Pedersen, 'Scriptum Johannis de Sicilia', 191-92 (J398); Celina A. Lértora Mendoza, 'El "Ars inveniendi eclipsim solis et lunae" copiado por Roberto Grosseteste', *Mathesis: filosofía e historia de las matemáticas* 5 (1989), 371-94, at 377.

a function of the argument of lunar latitude.[64] John of Genoa, even though he remained silent on their existence in his *Canones eclipsium* of 1332, would seek the assistance of such tables when he detailed the computational steps involved in predicting the annular solar eclipse of 3 March 1337.[65] Jean des Murs duly acknowledged their existence in the *Canones* of 1339, but only very briefly, as an alternative to the computational approach he had previously outlined on the basis of John of Genoa's *Canones eclipsium*.[66]

Another striking example of the influence John of Genoa exerted on our text is the section on how to adjust the time of mid-eclipse for the lunar parallax in longitude, which deviates conspicuously from what would have counted as common practice at the time. The principal sources for this common practice were the canons to the Toledan Tables, which instructed users to iterate the same calculation three times with successive approximations to the time of parallax-corrected or 'visible' conjunction.[67] Jean des Murs himself had at one point been a follower of this approach, as seen from the instructions included in his *Patefit* and the steps spelled out in his calculations for the solar eclipse of 1333.[68] A more elaborate method of parallax correction was taught in the canons composed by Jean de Lignères and his student John of Saxony, who both followed an iterative method first introduced to the Latin

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[64] See Chabás and Goldstein, *A Survey*, 163-74. The use of such tables was presupposed, for instance, in the standard canons for the Toledan Tables (Cb), Jean de Lignères's canons of 1322, and the eclipse canons by John of Saxony. See Pedersen, *The Toledan Tables*, 2:458-60 (Cb190); ch. 36 in MS Paris, Bibliothèque nationale de France, 7281, fols. 196v-7v; Martínez Gázquez, *Traducción castellana*, 117-24.

[65] John of Genoa's *Investigatio eclipsis solis anno Christi 1337* survives in MSS Paris, Bibliothèque nationale de France, lat. 7281, fols. 208v-10r, and Cambridge, University Library, Ee.3.61, fols. 75r-81r.

[66] *H*, fol. 146v.

[67] Pedersen, *The Toledan Tables*, 2:458 (Cb188).

[68] Jean des Murs, *Patefit*, pt. 2, *L*, fol. 209rb-vb; MS El Escorial, Real Biblioteca de San Lorenzo, O.II.10, fol. 92v.

West through the work of al-Battānī.[69] John of Genoa expressly abandoned both of these approaches in favour of a 'quick fix' that he alleged to have discovered himself, based on his reading of the *Almagesti minor*, a Latin treatise of the late twelfth or early thirteenth century:

> I have extracted this method from certain definitions that are placed at the start of the fifth book of the 'minor *Almagest*', notwithstanding the fact that when I looked for it I could not find the same parallax [method], neither there nor in al-Battānī nor elsewhere. Nevertheless, if you consider this well, you will see that this method is very brief and precise and easy.[70]

The 'definitions' John of Genoa had in mind here can indeed be found in the *Almagesti minor*, albeit at the start of the sixth rather than the fifth book. They include, but are not limited to, the following relevant items:

> The *superlatio* of the Moon for a given time is that which remains when the Sun's unequal motion for that time is subtracted from the Moon's unequal motion for that time. (*Superlatio lune ad datum tempus est id quod relinquitur cum diversus motus solis ad ipsum tempus subtractus fuerit a diverso motu lune ad ipsum tempus.*)

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[69] al-Battānī, *De scientia stellarum*, ch. 44, in *Continentur in hoc libro* (see n. 63), fols. 66r–67v. For Jean de Lignères, see ch. 36 of his canons of 1322 in MS Paris, Bibliothèque nationale de France, 7281, fols. 195r-96v. For John of Saxony, see Martínez Gázquez, *Traducción castellana*, 103-15.

[70] MS *L*, fol. 216vb: 'Secundo sciendum circa diversitatem aspectus in longitudine quod istum modum extraxi ex quibusdam diffinitionibus positis in principio libri 5 minoris Almagesti licet in querendo eandem diversitatem aspectus non viderim nec ibi, nec Albategni, nec alibi. Tamen, si bene consideres, videbis hunc modum valde brevem et precisum et facilem.'

> The Moon's apparent motion is the progression in longitude of the Moon's apparent place [as seen] through parallax. (*Visus motus lune est visi loci lune per diversitatem aspectus in longitudinem progressio.*)

> The Moon's apparent *superlatio* for a given time is that which remains when the Sun's unequal motion for that time is subtracted from the Moon's apparent motion for the same time. (*Visa superlatio lune ad aliquod tempus est, cum diversus motus solis ad ipsum tempus a viso motu lune ad idem tempus subductus fuerit, id quod relinquitur*.)[71]

Using these three definitions as a source of inspiration, John of Genoa conceived of the parallax correction involved in computing the time of mid-eclipse in fundamentally the same way as other astronomers approached Δt when computing the time of true syzygy. He accordingly sought to divide the lunar parallax in longitude at the time of true syzygy by the *superlatio* in order to obtain a time addition or subtraction that would lead to the 'apparent' time of true syzygy. The *superlatio* used in this computation had to be the 'apparent *superlatio*' or *superlatio visa*, which was itself a parallax-corrected value of the normal *superlatio*, as defined in the *Almagesti minor*. In order to obtain this value, John calculated the parallax for a second point in time, one hour before or after the true conjunction (depending on where this conjunction was located in relation to the zenith). By subtracting the first parallax (at true conjunction) from the second one (one hour before/after), John

[71] *Almagesti minor*, bk. VI, MS Paris, Bibliothèque nationale de France, lat. 16657, fol. 122r, available at https://ptolemaeus.badw.de/ms/2/2/122r. I here partly rely on the English translation in Henry Zepeda, ed., *The First Latin Treatise on Ptolemy's Astronomy: The Almagesti minor (ca. 1200)* (Turnhout, forthcoming). Many thanks to Dr Zepeda for sharing his work with me prior to publication.

obtained the variation in parallax over the course of an hour (*variatio diversitatis aspectus in una hora*). Adding or subtracting this *variatio* rendered the *superlatio* corrected and turned it into the *superlatio lune visa equata*. Jean des Murs’s *Canones* offered their readers a version of the very same method, as seen from the following sample:

John of Genoa:[72]	Jean des Murs:[73]
Et sic habes secundam diversitatem aspectus quam subtrahe a prima, si prima sit maior secunda, vel subtrahe primam a secunda, si secunda sit maior prima, et serva differentiam que vocetur ‘variatio diversitatis aspectus in una hora’. Deinde verum motum lune ultimo inventum compera ad locum lune tempore vere coniunctionis subtrahendo minorem a maiori. Similiter fac de motu solis et etiam lune in una hora, <tunc subtrahe motum solis a motu lune in una hora> et remanet superlatio lune in una hora, a qua subtrahe variationem diversitatis aspectus servatam, si locus coniunctionis distet a gradu ascendentis plus 90 gradibus zodyaci, et cum hec secunda diversitas aspectus fuerit maior quam prima. Si autem minor, adde. Si	Iam ergo habes duas diversitates aspectus. Minorem ergo *subtrahe* de maiori et *differentia vocatur ‘variatio diversitatis aspectus* lune in longitudine que tribuitur *un*i *hor*e’. *Deinde* compera verum locum lune *ultimo inventum* ad locum eius verum *tempore vere coniunctioni*, demendo *minorem* de *maiori*, et restat motus lune in una hora. *Similiter fac de motu solis* et habes *motum solis in una hora*. *Tunc* deme *motum solis* unius hore *a motu lune un*ius *hor*e et superest *superlatio lune in una hora, a qua* deme *variationem diversitatis aspectus* lune in una hora, *si locus vere coniunctionis dist*at *ab ascendent*e *plus 90 gradus zodiaci et cum hec secunda diversitas fuerit maior prima; si autem minor, adde*. Aut eandem variationem

[72] *L*, fol. 215r, with missing bit of text supplied from *D*, fol. 126v.

[73] *H*, fol. 145v.

autem locus coniunctionis distet a gradu ascendentis minus 90 gradibus zodiaci, adde ubi dixi ‘subtrahe’, et econtra. Et quod post additionem vel subtractionem provenerit erit visa superlacio lune equata.	diversitatis aspectus adde ad superlationem lune, si locus coniunctionis minus distat 90 gradus ab ascendente et cum hoc secunda diversitas fuerit minor prima; si autem maior, deme. *Et quod post* operationem exibit *erit equata superlatio lune visa*.

As with the previous example, Jean’s decision to adhere to John of Genoa for the purpose of his *Canones* made him break with conventional computational practice as well as with the approaches followed in his own previous works on mathematical astronomy. In the case of the parallax correction for the time of mid-eclipse, his switch to John of Genoa’s canons led him to endorse a crude simplification of his earlier practice, which raises the possibility that his recourse to this source served didactic rather than practical ends. One aspect of John’s *Canones eclipsium* that seems to have appealed to Jean des Murs was their succinctness compared to other canons of this type, which he enhanced even further in his own sections on solar and lunar eclipses. The latter, rather fittingly, were headed *De eclipsi solis breviter adequanda* and *De eclipsi lune breviter adequanda*—brevity being perhaps the key feature of the *Canones tabularum Alfonsii* of 1339.