Work Cohesion as a Test of Manuscript Transmission: The Case of John of Lignères' Tabule magne

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Introduction

The identification and analysis of the discrete elements or 'works' of mathematical astronomy in medieval manuscripts are complex. In the Latin sources, the corpus of mathematical astronomy is generally formed of multiple-text manuscripts. And inside a given codex, texts and table sets are often not copied one after the other; instead, parts of these elements are mixed according to different ordering methods. Hence, the identification and classification of the medieval Latin works of mathematical astronomy require expert knowledge and the ability to analyse, in some cases by means of statistical tools, elements deeply embedded in the content of the documents. The material aspects of manuscript transmission are thus finely intertwined with the intellectual aspects of mathematical astronomy. The usual approach to this issue has been to seek reliable identification tools for works, such as an incipit for a text or the morphology of quantitative material with regard to tabular content.[1] Within the framework of ALFA, and especially in the context of surveying the Alfonsine text corpus, we frequently rely on these well-established methods.

In this contribution, my aim is to take a different approach, to ask whether it is now possible to consider the complexity of manuscript transmission not only as a problem to solve in order to identify works but also as a resource to better understand the astro-

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1 Such methods have been developed over the last seventy years. Seminal works include E. S. Kennedy, 'A Survey of Islamic Astronomical Tables', *Transactions of the American Philosophical Society*, N. S. 46 (1956), 123–77, and for the Latin sources G. J. Toomer, 'A Survey of the Toledan Tables', *Osiris*, 15 (1968), 5–174. Several other works were completed in this style, the most recent and pertinent in the context of this chapter being José Chabás and Bernard R. Goldstein, *A Survey of European Astronomical Tables in the Late Middle Ages,* (Leiden: Brill, 2012) and José Chabás, *Computational Astronomy in the Middle Ages: Sets of Astronomical Tables in Latin,* (Madrid: Consejo Superior de Investigaciones Científicas 2019).

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nomical practices of historical actors. The complexity of the manuscript transmission of mathematical astronomical material in the Alfonsine milieus is, at least partially, the result of the choices of historical figures, namely, the ways in which they considered the texts they were copying, compiling, or composing.[2] Understanding these choices and attitudes could shed new light on the intellectual practice of mathematical astronomy in the Alfonsine context. The complexity of manuscript transmission might also convey information about the ways historical actors would or could work with the manuscripts they shaped in various contexts. Why did a particular scribe select a specific combination of texts in a manuscript? In what ways would this particular combination be useful later on? Which astronomical quantities can be computed, to what level of accuracy, and according to what method? What are the various astronomical phenomena that can be analysed and how can this be done?

Although these general questions are the drivers of this contribution, I do not address them directly or in their full generality. Instead, I shall consider the case of an individual work, and then allow the manuscript tradition of this work to inform me of its parts, how they are held together, and how they are reconfigured in different situations. This, in turn, allows me to raise the issue of the level of cohesion (or lack thereof) between the different parts of the work as completed by different historical actors. Together, this question and this approach clarify the aforementioned more general issues concerning the attitudes of historical actors towards written mathematical astronomical material and the consequences of their choices on the way they were able to interact with the manuscripts they produced.

John of Lignères' *Tabule magne* will be the subject of this analysis. This work, likely composed sometime between 1320 and 1325, includes a set of canons and tables.[3] It was integrated by its author in a larger collection of his works, which incorporated two treatises on instruments (the *saphea* and the *equatorium*).[4] Thus, the initial composition of the

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2 Most of the Alfonsine manuscripts were copied by fourteenth- and fifteenth-century hands and binding may, in some cases, have occurred much later (even in the nineteenth century); but in those cases, a material analysis of the codex often provides strong indications about the medieval organization of the codices.

3 Emannuel Poulle, 'John of Lignères', in *Dictionary of Scientific Biography*, ed. Charles Gillispie, 16 vols (New York: Scribners, 1970–80), VII (1973), pp. 122–28; John D. North, 'The Alfonsine Tables in England', in *Prismata, Naturwissenschaftsgeschichtliche Studien: Festschrift für Willy Hartner*, ed. Y. Maeyama and W.G. Satzer (Wiesbaden: Steiner, 1977), pp. 269–301; José Chabás and Bernard R. Goldstein, *The Alfonsine Tables of Toledo* (Dordrecht, Kluwer Academic Publishers, 2003), pp. 282-3; Chabás and Goldstein, *Survey*; José Chabás and Bernard R. Goldstein, 'The Moon in the Oxford Tables of 1348', *Journal for the History of Astronomy,* 47 (2016), 159–67; Chabás, *Computational Astronomy*, pp. 199–206.

4 'Feci unicum instrumentum modici sumptus levi ponderis, quantitate parvum, virtute et continentia magnum, quod et planetarum equatorium nuncupatur eo quia in eo faciliter eorum equationes habentur. Sed quia talium instrumentorum non sunt compositores ubique et etiam ubi sunt pauci reperiuntur perfecti, quia etiam per talia non ita precise veritas sicut per tabulas haberi potest, idcirco composui has permanentes tabulas in veritate perpetuas et omnium radicum susceptivas in quibus omnium tabularum labor excluditur et instrumentorum inprecisio amovetur. Post hoc igitur videns quod in opere tabularum instrumenta primi nobilis antecedunt. *Tria* illorum precipua adinvicem comparavi: speram scilicet solidam, astrolabium et sapheam Azerchelis […] *unum* composui instrumetum omnium instrumentorum predictorum vires ac etiam excellentias continens, quod etmerito universale astrolabium nuncupatur. […]' Paris, BnF lat. 10263, f. 71^{r} (I have made a unique, lightweight and low-cost instrument, which although small in size, is rich in virtues and content. It is called the equatorium of the planets, because it is easy to obtain their equations with it. But the designers of such instruments are not to be found everywhere, and of those that exist, very few are perfect, and thus with such instruments the truth cannot be obtained as precisely as it

text by John of Lignères is already interesting with respect to the issue of cohesion, firstly because the work is composed of two distinctive types of content (tables and canons), and secondly because this composite work was apparently integrated into a larger intellectual unit by its author.[5] The *Tabule magne* were important in the transmission of Alfonsine material in England,[6] but the text also circulated in other parts of Europe in the fourteenth and fifteenth centuries. Thus, different attitudes towards the *Tabule magne* are witnessed in the corpus, which might enlighten us on the subject of cohesion.

This chapter is divided in two parts: canons, and tables. In both parts, the same three steps are followed. Firstly, I briefly describe the manuscripts (date, place, content) in order to understand the intellectual profile of the scribes who produced them. Secondly, I detail the content of the work to see the topic addressed, the originality, and level of technicity of each table or canon included in it. Thirdly, I study how this content is organized in the different witnesses (omission, addition, ordering) in order to assess how each manuscript handles the canons, tables, and the relationship between them.

We see that the scribes transmitting the *Tabule magne* canons or tables have largely relied on the modularity of those writings to build different sets. Their art of compilation reveals the main components of the work, which seems to be expressed with more liberty in the more technical parts (canons on complex topics, or even more tables). Compilation thus can have different effects on canons and tables, suggesting that a straightforward procedural relation between both types of writings was not central for these scribes. These results also raise methodological issues surrounding the techniques used to identify texts and tables, respectively, and concerning the enterprise of preparing critical editions that I also discuss in the conclusion.

1. Canons to the *Tabule magne*

1.1. Manuscript witnesses

Among the seven manuscripts witnessing the canons to the *Tabule magne*, all but one concentrate on mathematical astronomy and astrology with highly technical content. On the other hand, John of Lignères emphasized in his dedication to Robert Bardis, Dean of Glasgow, that the purpose of the association of the *Tabule magne* with an *equatorium* and a *saphea* was to offer an autonomous and simple set of tools related to spherical and planetary astronomy.[7] The text of the canons (e.g., the arithmetical canons on addition

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can with tables. Thus, I have composed permanent tables, truly perpetual because all the roots are written on them, in which the work of all the tables is excluded, and the imprecision of the instruments is avoided. After this we see thus that, in the operation with tables, an instrument for the first mobile precedes. […] I composed an instrument …. deserving the name of universal astrolabe).

5 The first characteristic is very common in Alfonsine astronomy, the latter is more original. However, no manuscripts propose these three works together.

6 North, 'Alfonsine Tables in England', pp 273-4. See also, Boudet and Miolo, in this volume.

7 Two equatoria texts are attributed to John of Lignères; see Emmanuel Poulle, *Les Instruments de la théorie des planètes selon Ptolémée: Équatoires et horlogerie planétaire du xiiie au xvie siècle*, 2 vols (Geneva: Droz, 1980), I, pp. 363–74. Nothing in the text of the *Tabule magne* introduction indicates which of those two texts was intended to be associated with the saphea or the *Tabule magne*.

and subtraction) as well as some aspects of the transmitted tables (e.g., the double-argument tables for planetary equations or the time from mean to true syzygy) confirm this initial statement. Thus, a text designed by its author for an educated but non-technical audience was transmitted to us through manuscripts giving the perspective of a highly technical group of scribes and users. Many of the transmission phenomena attested in this manuscript tradition can be explained by this tension.

Erfurt CA 4° 349 is a manuscript, mostly on paper (except for ff. 78–97 and 160–61), of 171 folios.[8] It is composed of eight parts (ff. 1–77, 78–97, 98–120, 121–32, 133–45, 146–59, 160–61, and 162–71), likely assembled during the second half of the fourteenth century. The manuscript was copied by several French or English hands, including, for the first codicological part, that of Johannes de Wasia who is also probably responsible for a table of contents on the manuscript's fly-leaves.[9] It is thus likely that Johannes de Wasia assembled this manuscript during his presence at the University of Paris from 1369 to 1383. Johannes de Wasia's interests then turned towards theology and he finished his career as the first dean of the theology faculty at Cologne University, where he died in 1395. Johannes de Wasia authored several astronomical and mathematical works, from which some notes on the *Almagest* and a *Tractatus de proportionionibus* are copied in Erfurt CA 4° 349. He also composed a series of mean motions tables for the meridian of Paris and some *Questiones de spera*.[10] Johannes de Wasia owned an important collection of scientific manuscripts, which was later purchased by Amplonius Rating de Berka (1363–1435). Now preserved in Erfurt, they are an essential source for the study of early Alfonsine astronomy. Although he was perhaps not a first-rank Alfonsine astronomer, Johannes de Wasia was certainly competent in mathematical astronomy. The technical content of Erfurt CA 4° 349 reflects this. Mathematical astronomy texts from the pre-Alfonsine and Parisian Alfonsine milieus form the core of the manuscript's first codicological unit, with works from John of Lignères, Henry of Langenstein, and Petrus de Dacia. Other sections of the manuscript also reflect the Parisian milieu, with works by Geoffrey of Meaux and Franco of Polonia, for example. The larger influence of texts circulating in the Parisian arts faculty can be seen with the works of Oresme, or earlier authors like Grosseteste, Jordanus de Nemore, Alexander of Villedieu, or pseudo-Albert the Great. These texts concern mathematical astronomy, mathematics, computus, astrology, and natural philosophy (Grosseteste *De coloribus*). In this manuscript, the canons to the *Tabule magne* (ff. 11^{r}–17^{v}) are not identified by a title where they begin but by an explicit on folio 17^{v}: *Expliciunt canones magistri Johannes de Lineriis super tabulas magnas*.

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8 Wilhelm Schum, *Beschreibendes Verzeichnis der Amplonianischen Handschriften Sammlung zu Erfurt* (Berlin: Weidmannsche Buchhandlung 1887), pp. 583–87; David Juste, 'MS Erfurt, Universitäts- und Forschungsbibliothek, CA 4° 349' (updated: 14.11.2019), *Ptolemaeus Arabus et Latinus. Manuscripts*, URL: http://ptolemaeus.badw.de/ms/31.

9 For a short note on Johannes de Wasia, see David Juste, 'Johannes de Wasia, *Notes on the Almagest*' (updated: 29.10.2019), *Ptolemaeus Arabus et Latinus. Works*, URL: http://ptolemaeus.badw.de/work/75.

10 'Tabella radicum mediorum motuum subscriptorum ad annum domini 1369 completa ad meridianum Parisiensem per Iohannem de Wasia calculata', Erfurt 4° 362, ff. 13^{v}–14^{r} (table for the subscribed radices of the mean motion for the complete year 1369 at Paris meridian, calculated by Johannes de Wasia). The questions on the sphere can be found in Erfurt CA 4° 298, ff. 31^{r}–58^{r}.

Erfurt CA 4° 366 shares a similar profile.[11] Like 4° 349, 4° 366 is a student manuscript reflecting the advanced teaching of mathematical astronomy in the Parisian arts faculty in the mid-fourteenth century. The first part of the manuscript witnesses many works from the Parisian Alfonsine milieu. Interestingly, the second part of the manuscript presents texts from the earlier Toledan astronomy with, for instance, a fragment of the most common version of the canons to the Toledan Tables (f. 80). The canons to the *Tabule magne* are distinguished on folio 28^{r} with the following title: *Canones tabulas magne magister Johannes de Lineriis*. Erfurt 4° 366 is also important in the transmission of the *Tabule magne* because the text of those canons is followed by a commentary by John of Spira.

Cambridge Gonville & Caius MS 110 is a parchment manuscript of 368 pages.[12] It is formed of multiple codicological parts (1–19; 20–40; 41–100; 101–98; 199–294; 295–342; 343–62; 363–68), most of them from the fourteenth century. A note from R. Marchall along with a table of contents for the full manuscript found on page 20 indicates that the document was probably assembled in England during the fifteenth century. Although essentially technical, the manuscript seems to reflect a practitioner's collection rather than a university student's workbook. This practical rather than pedagogical orientation of the codex is indicated by the fact that the manuscript is mainly filled with 'almanacs' and features a full section on astrological computations (houses, aspects). The term 'almanac' was used by historical participants to refer to what appears to us today as distinct material. For instance, we find in the same manuscript an ephemerides by John of Saxony that is called 'almanac'.[13] Although assembled in England, the manuscript's most represented authors are John of Lignères and John of Saxony, thus showing a connection between the Parisian and English milieus in the practice of mathematical astronomy. The manuscript also transmits a version of the standard canons to the Toledan Tables. The canons to the *Tabule magne* are the opening piece of the document. They are introduced with the following title on page 1: *Incipiunt canones super magnum almanac omnes planetarum magistro Iohanne de Lineriis Ambianencis dyocesis composui super meridianum Parisiensem*. In coherence with the content of the rest of the manuscript, the *Tabule magne* are presented as an 'almanac'. In this context, we might understand this title as pointing to a practically-oriented set of tables and canons. The manuscript also transmits both the canons and the tables of the *Tabule magne*.

Paris BnF lat. Colbert 60 is a parchment manuscript of 182 folios.[14] Like the Cambridge manuscript, it is also a practitioner's collection assembled probably near the end of the fifteenth century from different codicological units produced in the fourteenth and fifteenth centuries. The practical orientation of the document is attested to, for instance, by the appearance of different types of arithmetical tables throughout the manuscript, some of which remarkably indicate an interest in decimal numbers. Although the manuscript

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11 Schum, *Verzeichnis*, pp. 612–14; Fritz S. Pedersen, *The Toledan Tables: A Review of the Manuscripts and the Textual Versions with an Edition* (Copenhagen: C. A. Reitzels Forlag, 2002), pp. 109–10. I was also able to consult a full digitalization of the manuscript.

12 Pedersen, *Toledan Tables*, p. 96. I was also able to consult a partial digitalization of the manuscript.

13 José Chabás and Bernard R. Goldstein, 'The Master and the Disciple: The Almanac of John of Lignères and the Ephemerides of John of Saxony', *Journal for the History of Astronomy*, 50 (2019), 82–96.

14 See https://archivesetmanuscrits.bnf.fr/ark:/12148/cc95559t (last consuled: 18.02.20). I also thank Alexandre Tur and José Chabás for information on this manuscript.

contains different almanacs, the central elements of the codex, in terms of content, are different versions of the Oxford Tables and the *Tabule magne*. Thus, Col. 60 also attests to a connection between Parisian and English milieus in the transmission of the canons to the *Tabule magne*. In this case, the *Tabule magne* somehow returned to the continent accompanied by new sets of tables produced in England. The canons to the *Tabule magne* are introduced on folio 34^{r} by an incipit almost identical to that of the Cambridge manuscript: *Incipiunt canones super magnum almanac omnes planetarum magistro Iohanne de Lineriis Picardi Ambianencis dyocesis composui super meridianum Parisiensem*. Col. 60, like the Cambridge manuscript, is also a rare witness transmitting the canons and tables of the *Tabule magne* in the same codex.

Prague KMK N.VIII is a parchment manuscript from the end of fourteenth century or the early fifteenth century, composed of 118 folios conserved in an early binding.[15] It is a composite manuscript with two distinctive parts in terms of content. The first contains the canons to the *Tabule magne* along with the initial part of John of Lignères' *Priores astrologi*. The remaining sections of the manuscript are purely theological. Although the example of Johannes de Wasia, encountered in Erfurt 4° 349, may confirm the existence of disparate textual configurations, it is difficult to see any kind of specific intellectual project that the composite codex might serve. The canons to the *Tabule magne* are not distinguished by any explicit or title in this manuscript.

Paris BnF lat. 7281 is a paper manuscript of 279 folios produced in the middle of the fifteenth century around Paris and northern France by the unidentified scribe, Jo. B.[16] While several hands add different kinds of marginal notes up until the sixteenth century, the main interest of the manuscript lies in its very peculiar collection and organisation of texts. The twenty-seven astronomical treatises constitute a sort of anthology of mathematical astronomy as perceived by an author towards the middle of the fifteenth century. In this very specific context, the canons to the *Tabule magne* are introduced on folio 201^{v} under the following title: *Canones super tabulas magnas per Johannes de Lineriis compilatas ex tabulis Alfonsi*. Thus, the connection of the set of tables to the Alfonsine Tables is quite clear. The table set is not described as an almanac, but Jo. B. uses the title attested in the two Erfurt manuscripts. Paris, BnF, lat. 7281 is neither a student nor a practitioner produced manuscript, but it is certainly a manuscript assembled by a skilled and very well-informed astronomer.

Paris, BnF lat. 10263 is a paper manuscript of 172 folios from the second half of the fifteenth century, copied in Naples by Arnaud de Bruxelles.[17] Written in a humanistic hand, it contains mainly texts. It belongs to a larger collection of BnF manuscripts attributed to Arnaud de Bruxelles,[18] an important humanist in the latter part of the fifteenth century. The large collection of scientific manuscripts associated with him demonstrates that he was

15 I thank Alena Hadravova for the information she provided on this manuscript.

16 Jean-Patrice Boudet, *Lire dans le ciel: La bibliothèque de Simon de Phares, astrologue du xve siècle* (Brussels: Centre d'Etudes des Manuscrits, 1994), pp. 175–89; see https://archivesetmanuscrits.bnf.fr/ark:/12148/cc66474 p. (last consulted 18 February 2020).

17 E. Poulle, *La Bibliothèque scientifique d'un imprimeur humaniste au xve siècle: Catalogue des manuscrits d'Arnaud de Bruxelles à la Bibliothèque nationale de Paris* (Geneva: Librairie Droz, 1963), pp. 45–53, See https://archivesetmanuscrits.bnf.fr/ark:/12148/cc71998b (last consulted: 18.02.20).

18 Paris, BnF lat. 10252, Paris, BnF lat. 10253, and Paris, BnF lat. 10263 to BnF lat. 10271.

also very well-informed in mathematical astronomy. The works of Arnaud de Bruxelles and Jo. B. demonstrate that the astronomical and intrinsic interest of the *Tabule magne* became associated with a more 'patrimonial' approach to the domain. In lat. 10263, the canons to the *Tabule magne* are introduced by the following incipit on folio 70^{r}: *Canones clarissimi mathematici Magistri Johannes de Lineriis Ambianensis diocesis amatoris scientie astrorum super tabulas per eum compositas ad inventionem motuum et locorum planetarum necessariorum ad iudicia astronomica*. Somehow, this title also indicates the practical orientation of the canons to the *Tabule magne*, and especially their astrological utility. These canons are immediately followed by John of Spira's commentary. The manuscript was intended to be coupled with Paris, BnF lat. 10264, which contains the table set of the *Tabule magne*.

This brief introduction to the seven witnesses shows that the text originated in Paris and circulated in England, Italy, Germany, and Central Europe. In these different regions, the text was transmitted in highly specialized manuscripts. These manuscripts suggest different contexts and historical participants in the transmission of the canons: students, practitioners, and scientific humanists. When present, the incipit or explicit to the canons also indicates different aspects of the work: its practical orientation as an 'almanac' and its link to astrological computation or to Alfonsine astronomy.

1.2. Content of the set of canons

From this point, it is possible to investigate more precisely how these different manuscripts organize the content of the *Tabule magne*. The texts seem to be composed of eleven separate canons or chapters.[19] Apart from the introduction, these canons can be gathered, for ease of description, into three different thematic groups. In summarizing the content of these different parts, I also signal possible parallels in canons that could have been known to John of Lignères.

The first thematic group addresses sexagesimal arithmetic with canons on addition, subtraction, and the computation of proportional parts.[20] It is common to find texts dedicated to the computation of proportional parts in astronomical canons, especially when this computation is made with the support of a specific proportional table, as is the case here. For instance, canon 9 of John of Lignères' *Priores astrologi* presents such a case.[21] It is less frequent to find separate canons specifically on the subjects of addition and subtraction. When these topics are addressed in canons, it is usually done in paragraphs inside another canon dedicated to a specific astronomical issue. For instance, a note on addition is inserted in the canons dedicated to mean motion (canon 5) of the *Priores astrologi*. A note on subtraction is incorporated into the canons concerning the true place of the sun in John of Saxony's *Tempus est mensura motus*. When composing the canons to the

19 The canons feature a little more than 6000 words.

20 The manuscript Erfurt CA 4° 366 uniquely adds a fourth canon to this section on arithmetic with an alternative and more general handling of proportional parts. It is probably an interpolation by Johannes de Wasia. Because it is uniquely attested in this manuscript, I do not consider this fourth canon in the following analysis. This shows that, in some contexts, historical participants had specific interests in these fundamental arithmetical questions. One may also think of the many arithmetical tables found in Paris, BnF Col. 60.

21 Marie-Madeleine Saby, 'Les Canons de Jean de Lignères sur les tables astronomiques de 1321: Edition critique, traduction et étude' (unpublished thesis, Paris, École Nationale des Chartes, 1987), p. 194.

Tabule magne, John of Lignères had probably already completed his *Algorismus minutiarum*, a specific arithmetical treatise on computation with usual and sexagesimal fractions. John of Lignères' choice to dedicate specific canons to these fundamental arithmetical issues echoes his explicit intention to provide, with the *Tabule magne*, an *equatorium*, and a *saphea*, that is, autonomous and simple mathematical tools for studying and computing spherical and planetary astronomy.

The second thematic group addresses questions of planetary astronomy in five canons. The central piece of this section is the canons on planetary equations that explain how to use the double-argument tables John of Lignères prepared for this specific purpose. This canon insists on the symmetries of the table layout and the way it can be read. It also precisely addresses the algebraic 'sign' of the equation obtained as the table entry with respect to the way the table is read. The interpolation procedures, unusual in this double-argument context, are presented in detail.[22] The mathematical approach to the computation of planetary equations is very original, but the canons do not pursue this aspect in depth. The computation of the true place of the Moon, although not unprecedented in the Latin sources, is also different from the conventional Toledan, Alfonsine, or *Priores Astrologi* approach.[23] The procedure of the *Tabule magne* relies on mean syzygy times and a double-argument table. This double-argument table gives the increment in longitude of the Moon which is to be added to its mean longitude at the preceding syzygy to obtain the true lunar place from its age and the mean lunar anomaly. The lunar canon insists on the same practical aspects of the computation, interpolation, and reading of the table as does the planetary equation canon. A canon concerning the computation of the true place of the Sun is also presented. On this topic, the *Tabule magne* follow a quite common procedure and the canon is very similar, for instance, to canon 13 of the *Priores astrologi*.[24] Finally, this planetary motion section also contains two canons that address planetary apogees and mean motions. These canons insist that computations be made for the meridian of Paris and explain in detail how they can be adjusted for a different meridian. In this respect, John of Lignères followed an option he had already adopted in his *Priores astrologi* canons.

The third and final group consists of two canons dealing with the computation of syzygies. The first explains how to find the first mean conjunction or opposition of a given year, and thus of all mean syzygies for that year. This is a very typical canon, of which equivalent versions can be found in the canons to the Toledan Tables or the *Priores astrologi*.[25] The second canon of this last group addresses the issue of computing the time from mean to true syzygy. It describes an algorithm relying on a double-argument table

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22 Matthieu Husson, 'Ways to Read a Table: Reading and Interpolation Techniques in Canons of Early Fourteenth-Century Double-Argument Tables', *Journal for the History of Astronomy*, 43 (2012), 299–319.

23 For a similar approach to this issue, see the tables of John Vimond and John of Murs: José Chabás and Bernard R. Goldstein, 'Early Alfonsine astronomy in Paris: The Tables of John Vimond (1320)', *Suhayl*, 4 (2004), 207–94; José Chabás, and Bernard R. Goldstein, 'John of Murs's Tables for 1321', *Journal for the History of Astronomy*, 40 (2009), 297–320.

24 *Priores astrologi's* set of canons is a little longer and more complex, because it precisely cross-references all the preceding canons on which the computation of the Sun's true place rely: for example, the computation of mean motion, apogees, mean argument, and proportional parts (Saby, 'Les Canons de Jean de Lignères', p. 199).

25 Saby, 'Les Canons de Jean de Lignères', pp. 260–64; Pedersen, *Toledan Tables*, pp. 446–49.

that gives the result of the division of the true elongation by the difference of the solar and lunar velocities. The described algorithm also relies on a table providing the equations and velocities of the two luminaries. This approach to the computation of true syzygies has precedent; for instance, it is described, among other possibilities, in canon 32 of the *Priores astrologi*.[26] However, in this latter case, the final division does not rely on a dedicated table but must be performed by the user.[27]

Hence, John of Lignères appears to have composed the canons to the *Tabule magne* by compiling different types of materials. Firstly, there are a few canons that rely on original or seldom used approaches to specific computations (e.g., planetary equations, true position of the Moon, or true syzygies). These canons appear to favour double-argument tables. Secondly, a set of much more common canons and procedures are provided, allowing the user to produce the initial data required for the more original canons. These more common canons often have very close parallels in the *Priores astrologi* or, for arithmetical canons, in the *Algorismus minutiarum*. There, John of Lignères adapted and re-used some of his previous work. Lastly, a general introduction is written, which unifies the set and ties it to two texts on astronomical instruments. Thus, the canons to the *Tabule magne* appear to be a somehow heterogeneous compilation of materials that might have been produced or borrowed by John of Lignères at different moments. We know nothing about the relationship between John of Lignères and Robert Bardis, but it could be that a specific opportunity presented itself and prompted the compilation of the work.

1.3. Organization of the manuscript witness content

Information regarding the various ways in which different manuscripts organise this content is presented in Figure 1. On the left of the table, the different canons are organized according to the thematic grouping I used to describe them above. At the top of the table, the shelf-mark of the manuscript is given. They are roughly chronologically ordered, left to right. At the intersection of a line and a column, one finds an ordinal number giving the rank of that particular set of canons in the manuscript. A cell with no ordinal number denotes the absence of the canon from the manuscript. Finally, when the absence of a given canon causes a procedural gap in the flow of the text, as presented in the witness, the concerned cell is shaded and an arrow points to the canon that would, in principle, not be applicable without the information of the missing one.[28]

Different manuscript witnesses present different parts of the work. One of the earliest witnesses, Erfurt 4° 349, proposes the most compact version of the text with only six canons: three on arithmetic and three on planetary motion. It completely ignores the issue of syzygies.[29] Furthermore, BnF lat. 10263, probably the latest witness, proposes the most comprehensive compilation of canons. This contrast between the two manuscripts

26 Saby, 'Les Canons de Jean de Lignères', p. 221.

27 For an earlier zij where a table is provided for division, see Ibn al-Kammād in José Chabás, and Bernard R. Goldstein, 'Computational Astronomy: Five Centuries of Finding True Syzygy', *Journal for the History of Astronomy*, 28 (1997), 93–105.

28 See the discussion in the next section for a definition of 'procedural gap'.

29 The scribe of the canons concluded them with an explicit showing that this shortened version was intentional.

		post 1300			circa 1400			ante 1500
		Erfurt Q 349	Erfurt Q 366	Cambridge G&G Ms 110	BnF, Mel. Col. 60	Prague Met. Chap. N VIII	BnF lat. 7281	BnF lat. 10263
Introduction	Multiplicis philosophie	1	1	1	1	1	1	1
Artihmetic	Modum additionis	2	2	2	2	2	2	2
	modum subtrahere	3	3	3	3	3	3	3
	veram partem proportionalem		4	4	4	6	4	6
Planetary	Locum augis	5	5	5	5			5
	medium motum	4	6	10	10	4		4
	dato centro medio et argumento vero…verum locum per tabulas	6	7	6	6	5	5	7
	Dato numerorum dierum…usque at 15 dies		8	7	7	9	6	9
	dato medium motus solis et verum locum eius invenire		9					10
Syzygies	tempus prime conjunctionis			9	9	7		8
	Tempus vere conjunctionis		10	8	8	8	7	11

Figure 1. Organization of the canons to the *Tabule magne* in the different manuscript witnesses.

cannot be directly correlated to the profile of the documents. Erfurt 4° 366, quite similar in style to Erfurt 4° 349, has only one canon missing. BnF lat. 7281, like BnF lat. 10263 (insofar as both present some sort of scientific-humanist view on the text), drastically offers only seven of the eleven canons. The most often omitted canon is that on the computation of the true place of the sun. It is interesting to note that its content is also among the least original of the work. The second most omitted canon is also a common one that deals with the computation of mean syzygies. On the other hand, only four canons are present in every manuscript witness: the introduction, the arithmetical canons on addition and subtraction, and the canon on planetary equation. The systematic presence of the canons on planetary equations is clearly understood as being central in the *Tabule magne*, since their most original contribution is the double-argument planetary equation tables. The case of the introduction canon is probably an artefact of the method of identifying works in manuscripts by their incipit. A manuscript giving the canons to the *Tabule magne* but omitting this first canon would not have been identified. Given the fluidity of the manuscript transmission of these kinds of texts, it is highly likely that many more manuscript witnesses of the canons will be found, once new methods for text identification are available.[30] It is more difficult to identify a reason for the systematic presence of the two rather elementary canons regarding addition and subtraction in a manuscript tradition that seems to have been produced by experts.

These variations in the collection of canons found in a given witness create a procedural gap in almost every manuscript, except for BnF lat. 10263, which is complete. All the other manuscripts present at least one procedural gap, that is, a canon that in principle would

30 The constantly progressing availability of digital surrogates for manuscripts and the improving performance of image processing and hand-written text recognition will certainly induce new methodologies and discoveries for this domain in the near future.

not be applicable because it requires information or a method from a missing canon. For instance, the computation of planetary positions begins with the computation of the planetary mean argument. This quantity is obtained as the difference between the mean longitude and the apogee of the planet. Manuscripts that lack the canons allowing the user to compute the apogee of a planet present a procedural gap with respect to the planetary equation canons. Similarly, the absence of canons on the true solar position or on the mean syzygies in some manuscripts yields a procedural gap with respect to the true syzygy canon.

The order of the canons is also an interesting indication of the procedural structure of the text. Let us consider the case of the canons for computation of proportional parts. In principle, this canon is to be used for the computation of interpolation in an equation (or any kind of non-linear) table. For a manuscript like Erfurt 4° 366, all the arithmetical canons are grouped together, followed by the equation canon. This manner of separating and isolating the arithmetical canons at the beginning of the text is a peculiar aspect of the canons to the *Tabule magne*. In this case and for this particular issue, the canons follow a procedural order. Three other manuscripts adopt the same organization for this canon on proportional parts.

Paris, BnF lat. 10263 does not break the procedural order, but adopts an additional ordering method. It presents the canon on proportional parts immediately before the canon on the equation, but the former is disconnected from the other arithmetical canons. The adopted ordering conforms to a frequent organisational method for canons, in which a specific mathematical set of instructions is given 'on the spot' where required, even at the cost of being repeated several times and in slightly different ways in the canons.[31] Prague Met. Chap. N VIII presents an ordering similar to that of BnF lat. 10263, but breaches the procedural order as the canon for proportional parts is presented immediately after the first equation computation canon.

Additional variations appear even on a more refined level of text analysis. For instance, BnF lat. 10263 has, at the end of the mean motion canon, a sentence relating it to the canon on apogees; at the same time, Erfurt, 4° 349, which shows the same succession for these two canons, lacks that sentence.[32] Of course, this sentence is also missing from Erfurt 4° 366. Going deeper, I have shown elsewhere that the interpolation procedures presented in these two manuscripts for double-argument tables are very different.[33] In fact, BnF lat. 10263 significantly simplifies the procedure and renders it independent of the astronomical context. Erfurt 4° 366 presents more complex procedures, which are sensitive to the astronomical nature of the arguments or to the astronomical object concerned (e.g. interpolation procedures for the Moon differ from those employed for the planets). This is a major modification to the text and might even change the planetary positions calculateed withthe tables.

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31 For instance, the computation of proportional parts is presented twice by John of Saxony in *Tempus est mensura motus*: Emmanuel Poulle, *Les Tables alphonsines avec les canons de Jean de Saxe: Édition, traduction et commentaire* (Paris: Éditions du Centre national de la recherche scientifique, 1984), pp. 64, 66–68.

32 '4^{us} canon de locis augis cuiuslibet et argumentis solis et centro aliorum 5^{e} planetarum invenendio', Paris, BnF lat. 10263, 74^{r} (Fourth canon regarding the position of apogee, used to find the argument of the Sun and the five planets).

33 Husson, 'Ways to Read a Table'.

A more general view of the ordering of the canons in the different witnesses raises other issues. BnF lat. 10263 begins with the two elementary arithmetical canons concerning addition and subtraction. Following this, a group regarding planetary true positions is presented with canons on mean motions, radices, proportional parts, and planetary equations. A group on syzygies is later presented with canons on mean syzygies, computation of the true lunar and solar places, and computation of true syzygies. Erfurt 4° 366 organizes and delimits these three series differently. The arithmetical series is more comprehensive and even includes the canons on proportional parts. The planetary equation group is, in fact, more of a true position group and also includes the canons on the Sun and Moon. The group on syzygies is reduced to only one canon and presents a procedural gap. In some cases, the ordering of the canons suggests that a given procedural gap was identified by the scribe, who chose to remedy the issue by adding one of the missing chapters to the end. This may be the case of the canon *dato numerorum dierum* found in Prague, Met. Chap. N VIII. A similar hypothesis can be proposed for the case of the canon *medium motum* in Cambridge, C&G MS 110 and BnF Col. 60.

The situation of the different canons is also diverse. For example, the beginning of the text is very stable; all manuscripts present the first three canons in the same order. By contrast, the canons on the computation of the true location of the Moon (when present) are always in a different position, ranging from rank 6 to rank 9.[34] It would appear as if canons copied later and presenting more technical content were more likely to be reordered, omitted, and modified.

The expert scribes who transmitted the canons to the *Tabule magne* have amplified the compilation aspect of the work by omitting different canons and variously ordering them. Apparently, some of the working habits adopted during the production of the canons are also those of the scribes who transmitted them. Even the content of the text can be modified, even in strategic places such as interpolation procedures. Hence, the manuscript tradition of the canons to the *Tabule magne* does not show a great concern for procedural coherence. This may suggest that the interests of the scribes of those witnesses were not confined by the procedural content of the canons. Perhaps they were able to supply the 'missing information' by other means, for example, from texts in a different part of the codex, from a different codex available to them, or simply from their own personal expertise. This kind of distant and open copying of a set of canons, initially created for a non-expert but educated audience, raises interesting research questions about the motivation of expert readers to copy such works. What does this tell us about the astronomical and computational practices of these experts?

The issue of the relation between canons and tables being one of the points of this chapter, it is important to briefly summarize how the canons refer to tables before we turn to the analysis of the table set in the manuscript tradition. We first note that not all canons are related to a specific table, including the introduction and the first two arithmetical canons. Strikingly, these are also the only canons that directly manipulate numerical content regarding specific quantities. All the other canons avoid discussion of any specific numerical examples but do refer to tables. They often do this by using a

34 Except, of course, for the two manuscripts presenting exactly the same ordering.

title for the table. They also describe the reading process for the table. These descriptions might refer to the layout of the table (including the step of the argument) and some of its non-numerical content, such as headings, units of measurement, or abbreviations, e.g., providing information on the 'additive' or 'subtractive' aspect of an entry. In these cases, thescanons, to a certain extent, constrain the type of table to which they can be directly applied. However, such textual constraints put on the table set by the canons are rather loose; by avoiding mention of the numerical content of the tables, the canons do not commit themselves to any specific values for astronomical parameters.

2. Tables of the *Tabule magne*

2.1. Manuscript witnesses of the tables

The twenty tables manuscripts, like those with the canons, confirm the presence of the work in Paris, England, Germany, Central Europe, and Italy. They would have circulated from the mid-fourteenth century to the end of the fifteenth century. Like the canons manuscripts, those transmitting the tables can generally be described as expert practitioners' codices, sometimes more carefully executed than others. The tables are not found, for instance, in a courtly presentation manuscript. Thus, the manuscript tradition suggests that the audience for the table set differs from the educated yet non-specialized users who were explicitly targeted by John of Lignères in the introduction to the canons. I distinguish three manuscript groups according to the relative proportions of text and tables they contain, as well as to the intellectual profiles of the codices.

Seven manuscripts contain only, or mainly, numerical tables.[35] They span a wide range of dates across the fourteenth and fifteenth centuries. Four of them have an identified geographical origin, either in Paris, Prague, Vienna, or Italy. Paris, BnF lat. 7286C is among the earliest manuscript of the corpus. It is a small (30x22 cm) parchment codex from the fourteenth century, featuring fifty-eight folios. It contains material produced by John of Lignères and John Vimond in the early 1320, when the Parisian Alfonsine Tables were most likely compiled. The tales by John Vimond are uniquely preserved in this manuscript. It is the first set attesting, in tabular format, parameters and theories specific to Parisian Alfonsine astronomy.[36] The section attributed to John of Lignères extends from folios 9^{r} to 56^{v} and essentially contains tables with the canons *Priores astrologi* and *Cuiuslibet arcus* copied in their margin as commentary. Most of the tables in this set are related to John of Lignères' Tables of 1322. Only two sub-sets, related to mean motions in years (ff. 10^{v}–11^{r}) and in hours or minutes of hours (ff. 23^{v}–24^{r}), can be connected to the *Tabule magne* thanks to their specific layout. Moreover, John of Lignères' Tables of 1322 derive from the standard version of the Toledan Tables.[37] The compilation of John of Lignères' Tables of

35 Erfurt CA 2° 388; Ajuda MS 52-XII-35; British Library Add Ms 24070; BnF lat. 7286C; BnF lat. 7300A; Vatican MS Pal. lat. 1374; Venice MS lat. VI 29.

36 José Chabás and Bernard R. Goldstein, 'John Vimond and the Alfonsine Trepidation Model', *Journal of the History of Astronomy*, 34 (2003), 163–70.

37 Chabás, *Computational Astronomy*, p. 193.

1322 with tables from the *Tabule magne* is a recurrent pattern in the manuscript tradition of the latter. Such. a compilation effect might occur because John Vimond and John of Lignères themselves were working in the same astronomical mileu at the same time.

The most important group of witnesses in the table manuscript tradition contains eleven elements. They are quite similar in style to those transmitting the canons.[38] These eleven manuscripts are evenly distributed over the fourteenth and fifteenth centuries and attest the presence of the *Tabule magne* in Paris, England, Germany, Central Europe, and Italy. They are astral science manuscripts dedicated mainly to mathematical astronomy and astrology. Two manuscripts of this group are described above in the section on canons: Cambridge, G&C Col. Ms 110 and Paris, BnF Col. 60. Erfurt 2° 376 is a typical witness of this group.[39] This is a mid-fourteenth-century manuscript of 102 parchment folios with an early leather and wood binding. It opens with works on the sphere (Sacrobosco, Peckham) and continues with the *Tabule magne*'s tables. The codex concludes with treatises on arithmetic, the astrolabe, and planetary theory. This collection of texts is an instance of what O. Perdesen called the *corpus astronomicum*.[40] In contrast to Paris, BnF lat. 7286C, this manuscript's table set is solely composed of tables that can be related to the *Tabule magne*. The first four folios (30^{v}–34^{v}) contain mean motion and mean syzygy tables. Folios 35^{r} to 53^{v} contain the planetary double argument equation tables.

Finally, two manuscripts transmitting the table include content that extends beyond astral sciences in the direction of the *scientiae mediae*, with, for instance, works on optics, music, or even natural philosophy.[41] They both date to the fifteenth century and come from Italy and Central Europe. Given the very low number of codices in this group, it is difficult to make any definitive statements about a potential meaning of this geographical and temporal distribution. On the other hand, the fact that only two out of the twenty table manuscripts have a scope going beyond the astral sciences supports our suggestion that the manuscript tradition of this text is predominantly technical and specialized. Bernkastel-Kues, Cusa MS 212 belonged to Nicolaus Cusanus. It is a 407-folio parchment manuscript mostly featuring works related to the astral sciences, but also Johannes Peckham's *Perspectiva communis* (239^{r}–250^{v}). In this manuscript, similarly to Paris, BnF lat. 7286C, what circulated under the incipit *Tabule Parisienses cum canonibus* is mainly composed of John of Lignères' Tables of 1322 with their canons in marginal notes. Two 'clandestine' elements from the *Tabule magne* are, however, incorporated: a set of apogees from 1320 to 1520 on folio 93^{r}, and a set of mean syzygy tables on folios 91^{v}–92^{r}. Paris, BnF lat. 10264 is especially important in the context of this paper because it is closely linked to the manuscript Paris, BnF lat. 10263 (described in the section on canons). Paris, BnF lat. 10264 is a large 286-folio paper manuscript related to Arnaud de Bruxelles.[42] Thus, many

38 Bernkastel-Kues, MS 210; Oxford, Hertford College, MS E.4; Cambridge, Gonville and Caius College, MS 110; Erfurt CA 2° 376; Erfurt CA 2° 384; Milan, MS N217 sup; BnF Col. 60; Vatican, MS Pal lat. 1367; Vatican MS Pal lat. 1376; Vatican, MS Pal lat. 1412; Venice, MS Cic 2309.

39 See https://ptolemaeus.badw.de/jordanus/ms/3356 (last consulted: 18.02.20).

40 Olaf Pedersen, 'The corpus astronomicum and the Tradition of Medieval Astronomy', *Studia Copernicana*, 13 (1975), 57–96.

41 Bernkastel-Kues, MS 212; BnF lat. 10264.

42 https://ptolemaeus.badw.de/jordanus/ms/4755 (last consulted: 18.02.20).

of the remarks I have made concerning Paris, BnF lat. 10263 also hold for this manuscript. The document begins (ff. 1^{r}–36^{r}) with a miscellany of astronomical tables, including most of the *Tabule magne*. Different arithmetical and proportion tables accompany them. These arithmetical tables cannot easily be linked to the *Tabule magne*, although they could be very useful in computing with the *Tabule magne*. Furthermore, folios 36^{v} to 56^{v} are left blank. Some of these folios are ruled with ink to leave templates for tables (e.g. 45^{r}). Arnaud de Bruxelles thus probably intended to complete the table set with some more material and left ample room to do so. The rest of the manuscript features texts on completely different topics, such as optics with Alhacen's *De perspectiva*, natural philosophy with Roger Bacon's *Opus tertiums*, and Albert the Great's *Cosmographia*. This kind of manuscript could be interpreted as showing a transmission of the *Tabule magne* in a less specialized context, perhaps targeted to the kind of users for which John of Lignères had compiled his work. However, in this case, Arnaud de Bruxelles and Nicolaus Cusanus were certainly first-rank practitioners of astronomy, not beginners.

One particularly interesting transmission phenomenon attested in this manuscript tradition, which is highly likely to be more common in table transmission, is the silent compilation of tables belonging to different sets. This phenomenon is almost never witnessed for the canon transmission of the *Tabule magne*,[43] where the transmitting scribes may omit canons, present them in different orders, and add, suppress, or modify sentences or paragraphs; but they do not blend multiple texts.[44] Perhaps when text identification methods more easily allow the identification of parts of texts rather than relying on the incipits, more complex phenomena of textual transmission will be identified. But already in our current set of twenty manusripts the existence of this compilation effect for tables shows a certain attitude of scribes and table compilers with respect to a table set. The *Tabule magne* are often mixed with John of Lignères' Tables of 1322.[45] Thus, they form a composite set of the two works that began to circulate very early in the mid-fourteenth and well into the fifteenth century, often as a complement to the Parisian Alfonsine Tables.[46] This early compilation of tables might be the consequence of a choice made by John of Lignères himself or at least in a milieu closely connected to him.[47] John of Lignères composed both sets during the same period of his life, roughly between 1320 and 1325. The impression I have is that compiling new tables and combining them into sets are two distinct processes. This leads to situations in which the same table is integrated into different table sets, some of which are dignified by the redaction of canons while others are not. The combination of tables from the *Tabule magne* and the Tables of 1322 lacks any set of canons. When incorporated into this larger set, the *Tabule magne* lose much of their practical, user-friendly qualities.

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43 Only one canon on proportional parts from Erfurt 4° 366 was discarded from the canons because it was present only in this witness.

44 Prague, MS N VIII, for instance, first features the canons *Multiplicis philosophie* and then the *Priores astrologi*, but the two texts are not blended together.

45 In some situations, John of Genoa's tables are also aggregated to this collection (see Laure Miolo, in this book).

46 Vatican MS Pal. lat. 1367 also offers an example of this phenomenon in the second group of manuscripts.

47 BnF lat. 7286C, or Erfurt 2° 388 and Erfurt 2° 376.

2.3. Table set content

Following the organization of the canons, the content of the table set can be described in three different thematic groups. The first group concerns planetary positions, the second syzygies, and the third arithmetical tables. In a similar fashion to the canons, some elements of these groups are original and have a strong identity, while others are more common and are often shared by multiple table sets.[48]

The group of tables dedicated to the computation of planetary position is the largest. It can be further divided into two sub-groups: mean motions and equations. For both, John of Lignères composed tables with specific layouts, ensuring a strong identity for the *Tabule magne*. Mean motion tables are given for the meridian of Paris, similar to the Tables of 1322. The two main tables for mean motions concern (i) the position of the true apogees of the Sun and the planets and (ii) the mean motions of the Sun, Moon, and planets. Both cover intervals of twenty years, but in different ways.[49] The apogee tables list the true apogees with a precision of seconds from 1320 to 1520 (complete years). The mean motion table displays, in the same grid, twelve useful mean quantities.[50] One grid is given for each of the main calendar units: years, months, days, hours, and minutes with a precision of seconds or thirds. These quantities are needed to operate an *equatorium* of the type John of Lignères associated with the *Tabule magne*. They are also required to employ the equation tables of the *Tabule magne*. The expanded and collected years are organized in one grid within the table for the the years. It begins by giving entries for each year from one to twenty, then for every twenty years up to 100, then for every hundred years up to 1000. It ends with a value for 2000 years. A set of radices for Paris in 1320 is associated to these mean motion tables. John of Lignères also uses this peculiar format for mean elongations in the Tables of 1322.[51]

The most voluminous of this thematic group on planetary motion are the tables for lunar and planetary equations. They are double-argument tables that provide the total equation and share a common layout; the head of the table (and its bottom line) display the mean centre, and the left and right columns display the mean anomaly at intervals of six degrees. This choice of layout and computational organization is very original and gives a strong identity to the *Tabule magne*. The format would continue in table making until the modern period and would spread globally, in both astronomical and trigonometrical contexts. John of Lignères' Parisian contemporaries, John of Murs and John Vimond, carried out further experiments with double-argument tables.[52] An echo of these experiments is found in an alternative double-argument table given to find the true lunar position. The first argument of the table is a number of days, from one to fifteen, representing the time elapsed since the preceding mean conjunction. The second argument, to the left of the table, is given

48 Descriptions here largely follow Chabás, *Computational Astronomy*, pp. 199–206.

49 The use of this period is, for instance, attested in the Castillan Alfonsine canons; cf. Chabás and Goldstein, *The Alfonsine Tables*, 2003.

50 Mean motion of the Sun, Venus, and Mercury; mean motion of the Moon, lunar centre; lunar anomaly, ascending lunar node, mean motion of Saturn; argument of Saturn, mean motion of Jupiter, argument of Jupiter, mean motion of Mars, argument of Mars, argument of Venus, and argument of Mercury.

51 Chabás, *Computational Astronomy*, p. 202.

52 Chabás and Goldstein, 'John of Murs's Tables'; Chabás and Goldstein, 'Early Alfonsine Astronomy'.

at intervals of six degrees from zero to 180 and represents the mean lunar anomaly. The entries of the table give the increment in longitude of the Moon to be added to its mean longitude at the preceding conjunction. Interestingly, the canons for the Moon describe this particular table and do not mention the first double-argument tables addressing the Moon's true position as that of any regular planet.[53] The solar equation table is entirely standard, with a maximum value of 2;10° reached at 92°-94°. It cannot be distinguished from that found in John of Lignères' Tables of 1322 or the Parisian Alfonsine Tables.

The second thematic group of tables concerns syzygy computation. For this group, the canons describe two subjects. The first concerns mean syzygies and refers to tables also found in the Tables of 1322. The entries provide mean motions of the two luminaries, the mean lunar anomaly, and the mean argument of lunar latitude. These values, for the meridian of Paris, are given for the first syzygy of January, at intervals of twenty-four years from 1321 until 1609. A table of expanded years gives the values for years from one to twenty-three; and a table of months gives them for the first day of each month from February through December.

There are distinct sub-tables for conjunctions and oppositions. The time of syzygy is given to seconds and the mean motions to thirds. A second group of tables concerns the computation of the interval between mean and true syzygy. The canons describe a double-argument table providing the result in hours and minutes of the division of the true elongation by the *superatio* or difference between the true velocity of the Moon and the Sun. When attested in the manuscript tradition, this table is often associated with, and in some case replaced by, another table that gives the equations and velocities of the Sun and Moon in one single grid at one-degree intervals. These velocity and equation tables are not described in the *Tabule magne* canons but in the *Priores astrologi* (although with an interval of six degrees). It is also found circulating in the Tables of 1322.

Finally, the canons also describe a proportion table that can be used to compute proportional parts in the context of interpolation. Such tables are found in the manuscript tradition of the *Tabule magne*, but they are common in many astronomical manuscripts and have very few distinctive characteristics. I have thus not yet attempted to describe them or associate them with our table set.

Like the compilation of the canons in the *Tabule magne*, the compilation of the table set appears to be organized around a few very specific tables that give the set its own identity. In the case of the *Tabule magne*, the most original tables are undoubtedly those of the planetary equations. However, the mean motion tables, organized as if for an instrument, and the division table for the computation of true syzygies, are also quite specific. Other more common tables are also found in the manuscripts, such as the solar equation, the table for mean syzygies, or the equation and velocity tables. They are borrowed from or shared with other table sets, compiled (or not) by John of Lignères, and are not necessarily described in the canons.

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53 José Chabás, and Bernard R. Goldstein, 'The Medieval Moon in a Matrix: Double Argument Tables for Lunar Motion', *Archive for History of Exact Sciences*, 73 (2019), 335–59 (pp. 352–56).

2.3. Manuscript content organization

It is now possible to address the issue of the ways the different manuscript witnesses of the table set arrange and organize this tabular content. I summarize the information in Figures 2 and 3. Figures 1 and 2 present their content similarly. In Figure 2, we see two different arrays one above the other, each with ten manuscripts divided broadly over the fourteenth and fifteenth centuries. When tables from a given group are present in a specific manuscript, the cell is numbered. Empty cells mark the absence of a group of tables. The number in the cell corresponds to the order in which the tables appear in the manuscript. In contrast to Figure 1, here I have not attempted, for several reasons, to define or even mark what could be a procedural gap in a table set. Firstly, tables from the *Tabule magne* are copied with many other tables from different sets. Thus, if the *Tabule magne* set were missing a table in a given manuscript, it is highly likely that the missing information would be provided by another table from a different set. Secondly, and more fundamentally, tables are not intrinsically procedural or even discursive objects. It is thus difficult to define a procedural gap for a table set without thereby projecting onto it some sort of procedure. More than two thirds of the cells in Figure 2 are empty. It is thus difficult to assess, from Figure 2, the relative frequency of the different table groups in the manuscript tradition. Figure 3 provides this information.

More than two thirds of the cells in Figure 2 are empty, in stark contrast to Figure 1 where only one sixth of the cells are empty. The same phenomenon can be seen from another comparison of numbers; four canons out of eleven (i.e. more than a third) are present in every manuscript witness of the canons, while the most represented table is attested in only half of the witnesses forming the table manuscript tradition. This information is important when comparing the manuscript traditions for the canons and the tables and points to a contrast between the types of transmissions that table and canon sets undergo in the manuscript milieus of these expert astronomers. Table sets are blended (that is, have fluid boundaries), whereas in the witnesses so far identified, canon sets are not. Figure 2, however, shows striking contrasts among the various manuscripts. Three manuscripts boast nearly half of the table appearances, while fifteen offer three or fewer. This manuscript distribution of tables from the *Tabule magne* might thus reveal different situations in which the codices originated.

The first group consists of three manuscripts that present an almost complete set from the *Tabule magne*: Paris, BnF Col. 60; Paris, BnF lat. 10264; and Cambridge, G&C Col. MS 110. These three witnesses are all related to the canons. The Colbert and Cambridge manuscripts contain a version of the canons; Paris, BnF lat. 10264 is closely related to Paris, BnF lat. 10263. The scribes of these manuscripts held together both sides of the work and seemingly proposed their 'edition' of it. Colbert 60 is the most complete witness. It orders the tables broadly in three groups. The first group of tables is related to the computation of mean motion, the second to the computation of syzygies, and the third to the computation of planetary positions. Manuscript 10264 also addresses these three topics, but in a different order; mean motions come first, followed by planetary positions, and, finally, syzygy computations. This order is more congruent with the general organization of the canons than is the one adopted by Colbert 60. The Cambridge manuscript, generally

		Post 1300									circa 1400
		Paris, BnF, Lat 7286C	Erfurt, UB, F 376	Cambridge, G&C Col. Ms 110	Milano, Ambrosiano, Ms N217 sup	Bernkastel-Kues, Cusa, Ms 210	Efurt, UB, F 384	Venice, Bib Naz Marciana, Ms lat VI 29	Vatican, Pal lat. 1374	Bernkastel-Kues, Cusa, Ms 212	Erfurt, UB, F 388
Planetary	radice for Paris 1320			6		2					
	Apogees			1	1	1	1	1		2	
	Mean motions	1	1	3		3					
	Solar equation										2
	True lunar longitude double argument										3
	Lunar equation double argument										
	Planetary equation double argument		3								1
Syzygies	Mean syzygies		2	2			2		1	1	4
	Solar and lunar Equations and velocities			4			3		2		
	True zysygies			5					3		
Arithmetic	Proportion tables			7							

		circa 1400									ante 1500
		Venice, Museo Civico correr, Ms Cic 2309	Paris, BnF, lat 7300A	Paris, BnF, Colbert 60	Vatican, Pal lat. 1412	Vatican, Pal lat. 1376	Oxford, Heford Col., Ms 4	Vatican, Pal lat. 1367	Lisbon, Ajuda, MS 52-XII-35	London, BL, Ms add 24070	Paris, BnF, lat 10264
Planetary	radice for Paris 1320			6	1						1
	Apogees	1		1			1				
	Mean motions			3	2						2
	Solar equation									1	
	True lunar longitude double argument			10		2		2			5
	Lunar equation double argument		1	8						2	
	Planetary equation double argument		2	9		1			1	3	4
Syzygies	Mean syzygies			2	3			1			6
	Solar and lunar Equations and velocities			5				3			7
	True zysygies			7							8
Arithmetic	Proportion tables			4				4			3

Figure 2. Distribution of the different tables in the manuscript tradition of the *Tabule magne*.

Number of witness per table (total number of witness is 20)	
Mean syzygies	10
Apogees	9
Planetary equation double argument	8
Mean motions	7
Solar and lunar Equations and velocities	6
radice for Paris 1320	5
True lunar longitude double argument	5
True zysygies	4
Proportion tables	4
Solar equation	2
Lunar equation double argument	2

Figure 3. Number of witnesses for the different tables in the manuscript tradition of the *Tabule magne*.

speaking, follows the same order as Colbert 60, to which it is closely linked, except that it entirely omits the topic of planetary positions.

Manuscripts from the second group place tables from the *Tabule magne* within a larger collection of tables, often related to John of Lignères' Tables of 1322. They do not present any kind of edition of the table set. They do, however, keep some elements of its identity and inform us about the core elements of the set. Comprised of twelve manuscripts, this group is the most important and suggests that expert users can blend table sets in ways that reveal their interests. An initial sub-group of manuscripts transmits the planetary equations. This is the case for six manuscripts.[54] Among them, only Erfurt 2° 376 and Erfurt 2° 388 also provide mean motions from the *Tabule magne* (the later only for mean syzygies). All the others have inserted equations from the *Tabule magne* into a different context. A manuscript such as Lisbon, Ajuda 52-XII-35 has extracted only the planetary equations and omitted solar and lunar equations. Another group of tables closely linked to the identity of the *Tabule magne* concerns mean motions. Six manuscripts have extracted this thematic set from the *Tabule magne* and enclosed it in another tabular context.[55] The extreme case in this group is Paris, BnF lat. 7286C, which keeps only the mean motion tables. Some manuscripts, such as Bernkastel-kues, Cusa MS 210, extend a little beyond this core and include the tables for apogees and radices. Others, like Erfurt 2° 384 or Vatican Pal. lat. 1367, extend the core in the direction of syzygy computations.

The final manuscript group is constituted by those manuscripts attesting only one small table from the *Tabule magne*.[56] In these manuscripts, the link to the *Tabule magne* has almost faded completely. These manuscripts are more difficult to identify than those of the first three groups. It is thus likely that many more manuscripts of this kind have not

54 Erfurt 2° 376; Erfurt 2° 388; Ajuda MS 52-XII-35; British Library Add Ms 24070; BnF lat. 7300A; Vatican MS Pal, lat. 1367.

55 Bernkastel-Kues, MS 210; Bernkastel-Kues, MS 212; Erfurt 2° 384; BnF lat. 7286C; Vatican MS Pal, lat. 1367; Vatican MS Pal, lat. 1412.

56 Oxford, Hertford College, MS E.4; Milan, MS N217 sup; Venice, MS Cic 2309; Venice, MS lat. VI 29.

yet been identified. All of the manuscripts in this final group attest the apogee table. This is probably because this table provided direct positions of apogees over a long period of time; hence, the table was simple and would have remained useful long after its creation.

Consequently, apogee tables are the second most frequent in the table manuscript tradition. The most frequent are mean syzygy tables. There was a rather constant interest in those tables over the two centuries of the manuscript tradition. This was not the case for the planetary equation tables, which rank third in terms of frequency; seven witnesses (of eight) are from the fifteenth century. The relative absence of this central group from the *Tabule magne* during the first century of its transmission is striking, as is the attestation only in the fifteenth century of the lunar equation double argument table.

Our analysis of canons showed that the one dedicated to these double argument tables was a favourite locus for editorial intervention by the scribe, especially with respect to interpolation patterns. Similarly, planetary equation tables are also a locus for editorial intervention. Lisbon, Ajuda, MS 52-XII-35 uses sixty-degree signs, two ink colours, and displays differences only from one column to the next. Paris, BnF lat. 10264 and Erfurt 2° 376 use sixty-degree signs and display differences horizontally and vertically. Erfurt 2° 388 uses thirthy-degree signs and does not display differences, and so on. These interventions on the layout of the table have some consequences for the type of scribal mistakes likely to arise, on these tables' relation to the canon and on the way they can be manipulated for computation. They might then change, to some extent, the computational results one gets when using a different table witness.

The *Tabule magne* table set, like its related canons, is organized around two core table sub-groups with strong identities. The most important is the planetary equation group. The mean motions group (including apogee, radices and mean syzygies) closely follows it. Much less original satellite tables are associated with these two cores. The paradigmatic case here is the solar equation table. The lunar double-equation table is also interesting because its rarity and late appearance in the manuscript tradition might imply that it is a latter addition. However, the type of manuscript transmission occurring for table sets is different from that appearing in the canons (at least given what can be known with the current identification methods of texts and tables). Table sets are blended together in pairs, while canon sets are not. This blending of table sets is not random; the breaks occur primarily around the core group of tables that constitute the *Tabule magne's* identity as a table set.

A group of manuscripts proposes in the same, or closely related codices, both canons and tables. For these manuscripts, the relation between tables and canons is not organized around a procedural concern. For instance, the Colbert 60 and Cambridge manuscripts have the same set of canons in the same order, but their tabular sets are different. For the other types of manuscripts witnessing the tables, the blending of the *Tabule magne* with other table sets results in different kinds of editorial interventions and makes the relation between tables and canons more complicated than a simple procedural reading of tables and table sets might suggest. Expert users, apparently, did not always rely on canons to understand how tables were to be manipulated; they were perfectly at ease in constituting hybrid table sets that actually relate to no specific canons. Hence, we might surmise that from the expert astronomer's perspective, the procedural relation of canons to tables became secondary and that some other dimensions of these two types of mathematical descriptions concerning celestial phenomena became more important. What these could

be and how they could be recovered from the extant sources remains an open research question.

Conclusion

In this survey of the *Tabule magne* manuscript tradition, I have attempted to identify the elements composing the works, their cohesion, the possible genealogy of the project, and its reception. This effort leads to different results concerning the *Tabule magne* themselves and the editing practices of different kinds of expert astronomers in the fourteenth and fifteenth centuries. It also raises more general methodological and historical questions.

The *Tabule magne* appear to have been composed in between 1320 and 1325. John of Lignères was, at the time, working towards composing various tables and related canons. Early in the period, he fixed the larger part of this work in his Tables of 1322 and their associated *Cuiuslibet arcus* and *Priores astrologi* canons. Later, in 1325, an opportunity was perhaps offered to him in relation to Robert Bardis and he compiled the *Tabule magne* with less, yet more original, tabular material, the canons *Multiplicis philosophie* and two instrument texts. In this context, it is important to note that the process of composing tables and canons and the process of compiling them in different works are distinct. Both the canons and tables sets are composed from the material at hand. They are structured around core elements with a strong intellectual identity. In the case of the *Tabule magne*, this core consists of tools for planetary equations and mean motions. It is complemented by certain satellite tables and canons, which are usually less original and possibly borrowed. The reception of the canons and tables in their manuscript witnesses shows this in the omission of the canons and tables or in the ways they were arranged in different orders according to patterns that respect the core elements of the work.

Tables were blended with tables from other works into sets that acquired a certain level of stability but to which no canons correspond. In these mixed table sets, the identity of the *Tabule magne* as a distinctive work may entirely disappear. Tables from the *Tabule magne* are often found mixed with tables from John of Lignères' Tables of 1322 in a set that complements the Parisian Alfonsine Tables. This mixed set might reflect the more extended tabular material from which John of Lignères composed, respectively, the *Tabule magne* and the Tables of 1322. The *Tabule magne* were probably intended for an educated but non-expert audience. However, the manuscript tradition known to us suggests the reading and editorial interventions by expert practitioners of astronomy. Their editorial interventions reveal much about the cohesion of the work and its possible genealogy, because they underline the core elements around which the *Tabule magne* are organized. These interventions modify, in some cases, very intricate details of the canons and tables by changing the layout, types of sexagesimal numbers, or even interpolation procedures. Overall, the editorial intervention of the expert practitioners who transmitted the *Tabule magne* to us indicate that they might have been interested in more than a procedural reading of the canons and uses of the table set. The relation between the canons and the tables is too distant. A reader with no knowledge of their procedural relation would have many difficulties in inferring how table sets and canons can be used together from these manuscripts.

In this work, I have suggested that historians of astronomy address the variability of the manuscript transmission of mathematical astronomical texts not as a problem to overcome in the identification and critical edition of texts but as a resource to better understand how historical actors worked with their textual and tabular material. This proposition raises two separate questions. The first concerns the method of text and table identification, in particular, the incipit method for identifying texts and the morphological approach for identifying tables. My conclusion depends on these two identification methods, yet they also reveal that compilation, in various forms, was a distinctive feature of the intellectual habits developed in late medieval scholarly milieus. Recent research on canon texts in Alfonsine astronomy shows that redactors of canons also actively compiled materials. These compilations can gain cohesion, over time, and become authoritative texts attributed to named authors, such as John of Saxony's *Tempus est mensura motus* or John of Lignères' *Priores astrologi*.[57] As digital humanities progress, it may soon be possible that methods of text identification, relying on the analysis of digital surrogates of manuscripts, will be more sensitive to textual parts than is today's incipit method. In this new context, it may be possible to further fine-tune the conclusions derived here. For instance, one might distinguish, on a larger scale and more meticulously, the canon texts built as compilations from those that are compositions of another kind or are even dignified as authorities.

A second question emerging from my approach deals with the nature of 'critical editions'. Many critical editions, over centuries stretching back to the Renaissance, have been built around the notion of the 'author' composing a no longer accessible *Urquelle*. In the case explored in this chapter, however, 'authorial agency' was largely counteracted by the editorial interventions of the expert practitioners who transmitted the textual and tabular material from the milieus where the work first emerged. A critical edition, recognizing these dynamics, should attempt to reveal the different voices of the *Tabule magne's* manuscript tradition.

Manuscripts sources of the *Tabule magne*

Canons

Cambridge, Gonville & Caius College, 110, pp. 1–5 (England, mid-fourteenth century)
Erfurt, Universitätsbibliothek, CA 4° 349, 11^{r}–17^{v} (Paris, second half of the fourteenth century)
Erfurt, Universitätsbibliothek, CA 4° 366, 28^{r}–32^{v} (Paris, mid-fourteenth century)
Paris, Bibliothèque nationale de France, lat. 7281, 201^{v}–205^{v} (Paris, mid-fifteenth century)
Paris, Bibliothèque nationale de France, lat. 10263, 70^{r}–78^{r} (southern Italy, second half of the fifteenth century)
Paris, Bibliothèque nationale de France, Col. 60, 34^{r}–36^{r} (Paris, fifteenth century)
Prague, Knihovna Metropolitní kapituly, N VIII, ff. 1^{r}–10^{v} (Prague, fifteenth century)

57 Nicholas A. Jacobson, *Ordering Language to Order the Heavens: On Alfonsine Astronomical Canons (1350–1500)* (Turnhout: Brepols, forthcoming).

Tables

Bernkastel-Kues, Bibliothek des St Nikolaus-Hospitals, Cus 210, 89^{v}, 103^{r}–117^{r} (mid-fifteenth century)
Bernkastel-Kues, Bibliothek des St Nikolaus-Hospitals, Cus 212, 91^{v}–93^{r} (Italy, 1415–21)
Oxford, Hertford College, 4, 57^{v} (England, mid-fifteenth century)
Cambridge, Gonville & Caius College, 110, pp. 7–18 (England, mid-fourteenth century)
Erfurt, Universitätsbibliothek, CA 2° 376, 30^{v}–53^{v} (Paris, mid-fourteenth century)
Erfurt, Universitätsbibliothek, CA 2° 384, 26^{r}–28^{v} (1346–55)
Erfurt, Universitätsbibliothek, CA 2° 388, 1^{r}–42^{v} (fifteenth century)
Lisbon, Biblioteca da Ajuda, 52-XII-35, ff. 67^{r}–92^{v} (fifteenth century)
London, British Library, Add Ms 24070, ff. 24^{v}–42^{v} (fifteenth century)
Milano, Biblioteca Ambrosiana, N217 sup, f. 26^{v} (Cremona, mid-fifteenth century)
Paris, Bibliothèque nationale de France, Col. 60, ff. 36^{v}–62^{v} (fifteenth century)
Paris, Bibliothèque nationale de France, lat. 7286C, ff. 10^{v}–11^{r}; 23^{v}–24^{r} (Paris, mid-fourteenth century)
Paris, Bibliothèque nationale de France, lat. 7300A, ff. 94^{v}–112^{r} (fifteenth century)
Paris, Bibliothèque nationale de France, lat. 10264, ff. 1^{r}–28^{v} (southern Italy, second half of the fifteenth century
Vatican, Biblioteca Apostolica Vaticana, Pal. lat. 1367, ff. 60^{v}–62^{r} (Bavaria, mid-fifteenth century)
Vatican, Biblioteca Apostolica Vaticana, Pal. lat. 1374, ff. 26^{r}–27^{v}, 51^{v} (Prague, 1407)
Vatican, Biblioteca Apostolica Vaticana, Pal. lat. 1376, ff. 46^{r}, 102^{r}–130^{r} (Regensburg, 1447–58)
Vatican, Biblioteca Apostolica Vaticana, Pal. lat. 1412, ff. 95^{r}–123^{r} (Paris, 1453–54)
Venice, Museo Civico Correr, 2309, ff. 71^{r} (Italy, fifteenth century)
Venice, Biblioteca Nazionale Marciana, lat. VI 29, f. 77^{r} (Italy, second half of the fifteenth century)

Other manuscript sources

Erfurt, Universitätsbibliothek, CA 4° 298
Erfurt, Universitätsbibliothek, CA 4° 362
Paris, Bibliothèque nationale de France, lat. 10252
Paris, Bibliothèque nationale de France, lat. 10253

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