Alfonsine Astronomy: The written Record. Introduction

Richard L Kremer, Matthieu Husson, José Chabás

RICHARD L. KREMER, MATTHIEU HUSSON
AND JOSÉ CHABÁS

Introduction

Setting the Context

The ALFA Project is devoted to the study of the history of mathematical astronomy, that is, the art of computing astral positions, as it was practiced in Europe from the end of the thirteenth century to well into the sixteenth century. The discipline was structured around the Alfonsine Tables, a large set of astronomical tables with canons by Isaac ben Sid and Judah ben Moses ha-Cohen. Compiled circa 1271 in Toledo under the patronage of Alfonso X of Castile, this work was heir to Arabic astronomical traditions developed across the Iberian Peninsula during the previous two centuries. Beginning in 1320, the Castilian Alfonsine Tables were recast in Paris, resulting in what we now call the Parisian Alfonsine Tables. These materials circulated widely and fostered astronomical activities throughout Europe. Alfonsine astronomy was shaped around this set of tables and a significant number of new works were produced: texts explaining the use of tables (called canons), texts on astronomical instruments, mathematical and theoretical texts, almanacs, calendars, and ephemerides (lists of eclipses or of daily positions of all the planets). Together, these materials form the corpus of Alfonsine works, of which there are a few hundred, extant in more than 900 manuscript codices and dozens of printed editions. These manuscripts and imprints comprise the written record of Alfonsine astronomy and provide the focus of this volume.

We are not the first, of course, to consider these particular astronomical sources preserved in major European libraries. Earlier generations of bibliographers and cataloguers identified and described many of the Alfonsine manuscripts and the individual works they contain, even if they did not envision the material as an 'Alfonsine corpus'.[1] More recent scholarship has focused on the individual works, usually the tables and canons of

* This work was supported by the European Research Council project ALFA: Shaping a European scientific scene, Alfonsine astronomy, CoG 723085, PI Matthieu Husson. The papers collected here were presented and discussed at an ALFA Conference, held September 2019 in Prague.

1 Cf. J. C. Houzeau and A. Lancaster, *Bibliographie générale de l'astronomie*, 2 vols, new ed. (Brussels: Xavier Havermans, 1964); Wilhelm Schum, *Beschreibendes Verzeichniss der amplonianischen Handschriftensammlung zu Erfurt* (Berlin: Weidmannsche Buchhandlung, 1887); Ernst Zinner, *Verzeichnis der astronomischen Handschriften des deutschen Kulturgebietes* (Munich: Beck, 1925); Lynn Thorndike and Pearl Kibre, *Catalogue of Incipits of Mediaeval Scientific Writings*, rev. and augmented ed. (Cambridge: Mediaeval Academy of America, 1963); Ernst Zinner, *Geschichte und Bibliographie der astronomischen Literatur in Deutschland zur Zeit der Renaissance*, 2d ed. (Stuttgart: Hiersemann, 1964). For the more recent concept of an 'Alfonsine corpus', see José Chabás and Bernard R. Goldstein, *The Alfonsine Tables of Toledo* (Dordrecht: Kluwer, 2003), pp. 248–49.

medieval computational astronomy.[2] It has richly documented the intellectual content of the computational tools by identifying the structural frames of tables (sidereal or tropical longitudes), the underlying numerical parameters and mathematical algorithms, treatment of the motions of the eighth sphere, and the procedural steps required to compute positions with the tables. However, the number of manuscripts considered has remained relatively small, and the relations among works found in given codices and among various codices collected by given actors have not been thoroughly explored.[3] Considering the 'Alfonsine corpus' rather than simply isolated, individual works can give us new insights into the practice of mathematical astronomy in medieval Latin Europe.

In light of this, the ALFA Project and the authors of this volume aim to follow the development of Alfonsine astronomy on the manuscript level. What can the codices tell us about how medieval astronomers actually computed eclipses? What notions of 'efficiency' drove them to rearrange tables to enhance their user friendliness?[4] How did they compare and select among the differing computational tools available to them? Did they ever evaluate their computational results against empirical or philosophical evidence? How did they arrange copies of tabular works and other textual materials in individual codices or as books in their personal libraries? How did the practices of manuscript cultures (and, later, early print cultures) shape the practices of mathematical astronomy? In the contexts of manuscript and print, how did the demands of the university impact the teaching and understanding of mathematical astronomy? By what vehicles did mathematical practices travel to different milieus within Europe? Finally, how did Arabic, Hebrew, and Byzantine Greek materials intermingle with Latin and vernacular manuscripts across the fourteenth and fifteenth centuries? By following the manuscripts, we hope to uncover details about 'how they worked' that are generally not recoverable

---

2 Examples include G. J. Toomer, 'A Survey of the Toledan Tables', *Osiris* 15 (1968), pp. 5–174; Francis S. Benjamin, Jr., and G. J. Toomer, *Campanus of Novara and Medieval Planetary Theory:* Theorica Planetarum (Madison: University of Wisconsin Press, 1971); Bernard R. Goldstein, *The Astronomical Tables of Levi Ben Gerson* (New Haven: Archon Books, 1974); J. 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; 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); Mercè Comes, Roser Puig, and Julio Samsó (eds), *De Astronomia alphonsi regis* (Barcelona: Universidad de Barcelona, 1987); Marie-Madeleine Saby, 'Les Canons de Jean de Lignères sur les tables astronomiques de 1321: Édition critique, traduction et étude', unpublished thesis, Paris, École Nationale des Chartes, 1987; Fritz S. Pedersen, *The Toledan Tables: A Review of the Manuscripts and the Textual Versions with an Edition* (Copenhagen: C.A. Reitzels Forlag, 2002); Beatriz Porres de Mateo, '*Les Tables astronomiques de Jean de Gmunden: Édition et étude comparative*', unpublished PhD thesis, Paris, École Pratique des Hautes Études, 2003; José Chabás and Bernard R. Goldstein, *The Astronomical Tables of Giovanni Bianchini* (Leiden: Brill, 2009); idem, *A Survey of European Astronomical Tables in the Middle Ages* (Leiden: Brill, 2012); Benno van Dalen, *Islamic Astronomical Tables: Mathematical Analysis and Historical Investigation* (Farnham: Ashgate, 2013); José Chabás and Bernard R. Goldstein, *Essays on Medieval Computational Astronomy* (Leiden: Brill, 2015); José Chabás, *Computational Astronomy in the Middle Ages: Sets of Astronomical Tables in Latin* (Madrid: Consejo Superior de Investigaciones Científicas, 2019); Matthieu Husson, Clemency Montelle and Benno van Dalen (eds), *Editing and Analysing Astronomical Tables: Towards a Digital Information System for the History of Astral Sciences* (Turnhout: Brepols, 2022).

3 By way of comparison, a recent critical edition of the Toledan Tables examined more than 250 manuscripts. Pedersen, *Toledan Tables*, pp. 37–43.

4 José Chabás and B.R. Goldstein, 'Computing Planetary Positions: User-Friendliness and the Alfonsine Corpus', *Journal for the History of Astronomy*, 44 (2013), 257–76.

when the surviving historical documents were produced hundreds of years after the initial composition of the texts.

Our choice to follow the manuscripts raises several implications. Firstly, many of the earlier cataloguers were not historians of mathematical astronomy and thus did not always recognize the complexity of materials recorded in the manuscripts. For reasons explored by some of the essays in this volume, much of the Alfonsine corpus has been preserved in what are called composite manuscripts, codices that contain a wide range of diverse material. It is not uncommon to find various sets (or partial sets) of astronomical tables and canons, mathematical texts, texts on instruments, theoretical texts from university curricula, computational notes, texts on medical or meteorological astrology, computus material, and star catalogues mixed together in a single codex. Conversely, rarely do we find only one work in one book. By attending to the manuscript level, the ALFA Project is uncovering new works, new authors, and new relationships among tables, findings that will both deepen and broaden our understanding of Alfonsine astronomy.

Secondly, considering the physical materiality of the manuscripts can yield new information about the contexts in which Alfonsine astronomy was practiced. Marks of ownership can reveal early users, owners, or collectors; scribal colophons, watermarks, and bindings can localize places of production; marginal glosses or computations, underlining, rubrication, and soiled or heavily thumbed folios can suggest how some codices were 'used'. The types of materials bound into a composite manuscript can indicate whether the book was initially intended for a monastery library, a university classroom or professor's study, a courtly patron, or a specialized 'professional' such as a physician, consulting astrologer, calendar maker or mathematician. With such evidence, we can start to track Alfonsine astronomy as a European-wide scientific achievement and a set of practices involving many actors, milieus and sites.

Thirdly, by developing digital tools to manage and interrogate more than 900 manuscript codices carrying hundreds of works and thousands of copies of various astronomical tables, the ALFA Project can explore large-scale trends that have remained hidden to previous generations of scholarship. We do not intend to create a critical edition of the Parisian Alfonsine Tables, extant in more than 170 manuscript witnesses, but we can ask which types of tables were more frequently copied or commonly grouped with others or with texts. We can ask whether particular tables are found mostly in Italy, England, or Central Europe (Cracow, Prague, Vienna). We can track the strategies of early collectors, like William Reed in Oxford or Johannes de Wasia in Paris, who appear to have deliberately assembled copies of Alfonsine material for historical posterity rather than computational or pedagogical use. And once we are able to add machine reading to our repertoire of digital tools, we might explore, at ever finer levels of granularity, the movement of individual tables across the corpus of Alfonsine manuscripts.

The essays in this volume were written before ALFA's digital tools were fully functional. Rather than offering surveys based on 900 manuscripts, these essays present case studies of selected manuscripts or smaller groups of manuscripts. They illustrate the kinds of questions we can ask when conducting a history of Alfonsine astronomy at the manuscript level. More synthetic and integrative studies of the Alfonsine written record will be published during the third and final phase of the ALFA Project, after we have completed a second phase which will examine mathematical practices in the corpus.

Part 1: Alfonsine codices in circulation and collections

The essays of Part 1 examine individual manuscripts containing Alfonsine works. The authors of these essays seek not merely to list the contents, but also to reconstruct the cultural, astronomical, and mathematical worlds in which the manuscripts were initially copied, compiled, used, and collected. In some cases, individual scribes, patrons, owners, and even bookbinders can be identified from physical evidence in the surviving codices. In others, the original books have disappeared, forcing our authors to examine early inventories, library catalogues, or other references to manuscripts once known. Drawing on various types of evidence, the essays of Part 1 seek to contribute to the history of the book as well as to the history of astronomy.

The essays of Part 1 also illustrate a feature of Alfonsine astronomy that sets it apart from most other early traditions of the astral sciences. Surviving Alfonsine codices are usually contemporary, or nearly so, with the composition of the texts they contain. Most surviving sources for early Babylonian, Chinese, Greek, Sanskrit, Persian and Arabic astronomies are preserved as individual tablets or manuscripts created centuries after astronomers had initially authored the materials.[5] The Alfonsine manuscript corpus, therefore, offers historians a level of direct physical evidence about astronomical practice and manuscript culture that is not often available for other early astronomical traditions. The essays in Part 1 seek to interrogate this evidence at the level of the individual codex.

Laura Fernández Fernández reviews what is known about undoubtedly the most highly coveted manuscript of Alfonsine astronomy, the missing copy of the Castilian Alfonsine Tables, composed in the 1270s by two scholars, Isaac ben Sid and Judah ben Moses ha-Cohen, at the court of Alfonso X. Piecing together evidence assembled by earlier historians and from newly discovered sources, Fernández considers how the Castilian canons and tables might have travelled to Paris by the 1320s. Moreover, she discusses early reports of French and Italian translations, and how the Parisian Latin version circulated back to the Hispanic Kingdoms of the fourteenth and fifteenth centuries. She also pinpoints several references, in sixteenth-century and later book inventories and sales catalogues, to illuminated copies of Castilian 'Alfonsine Tables' and wonders whether an illuminated manuscript, produced in Alfonso's scriptorium and now held at the Parisian Bibliothèque de l'Arsenal, may once have contained a copy of the Castilian Alfonsine Tables.

Jean-Patrice Boudet and Laure Miolo examine a codex now at the Bodleian Library. A composite manuscript compiled and bound by William Reed, a fellow at Oxford's Merton

---

5 For introductions to the preservation of sources in these traditions, see Eleanor Robson, 'Reading the Libraries of Assyria and Babylonia', in *Ancient Libraries*, ed. Jason König, Katerina Oikonomopolou, and Greg Woolf (Cambridge: Cambridge University Press, 2013), pp. 38–56; Mathieu Ossendrijver, *Babylonian Mathematical Astronomy: Procedure Texts* (New York: Springer, 2012); Nathan Sivin, *Granting the Seasons: The Chinese Astronomical Reform of 1280, with a Study of Its Many Dimensions and a Translation of Its Records* (New York: Springer, 2009), pp. 227–47; Olaf Pedersen, *A Survey of the Almagest, with Annotation and New Commentary by Alexander Jones* (Berlin: Springer, 2011), pp. 11–25; Clemency Montelle and Kim Plofker, *Sanskrit Astronomical Tables* (Cham: Springer, 2018); E. S. Kennedy, 'A Survey of Islamic Astronomical Tables', *Transactions of the American Philosophical Society*, N. S. 46 (1956), 123–77; David A. King, Julio Samsó, and Bernard R. Goldstein, 'Astronomical Handbooks and Tables from the Islamic World (750–1900): An Interim Report', *Suhayl* 2 (2001), 9–105; Benno van Dalen, 'A New Survey of Islamic Astronomical Handbooks with Descriptions of More Than 200 Arabic and Persian Zijes' (unpublished manuscript, 2007).

College from 1344–57, this codex reveals a 'community of learning' at this College, since most of its texts were authored by Oxford masters or Merton fellows during the middle third of the fourteenth century.[6] Boudet and Miolo show how astronomer and bibliophile William Reed assembled a large personal library and then donated hundreds of books to several college libraries. In the Bodleian manuscript, they argue, Reed 'consciously gathered' materials concerning the astral sciences written by his contemporaries, and he presented them for use by the next generation of Oxonian scholars. To illustrate some of the practices reflected in Reed's codex, Boudet and Miolo examine in more detail a solar almanac, computed from the Parisian Alfonsine Tables for the years 1341–44; a list of planetary conjunctions and related astrological interpretations; and a precisely computed birth horoscope for a date in 1317. This single codex thus reveals the interests of mid-century Merton scholars in theoretical texts on astrometeorology, the computation of planetary positions and eclipses, and practical astrological prediction.

In his essay, **Richard L. Kremer** investigates another composite manuscript that he labels a 'toolbox', compiled at the end of the fifteenth century by a well-known Swabian astrologer and calendar maker, Marcus Schinnagel. In the 1480s, Schinnagel had produced, for an unknown patron, a large polyptych (1 × 3 metres in size, with multiple wings) compendium of astrological and calendrical texts, astronomical tables, and eclipse predictions. Kremer argues that the toolbox manuscript, now held at the British Library, is closely related to the content of the polyptych. Both sources combine much material copied from astronomical texts printed in Southern Germany during the late fifteenth century. Observing how Schinnagel snatched individual tables from different sources (especially from the 1492 printed edition of the Parisian Alfonsine Tables), rearranging their order in the codex, and dropping in several of his own newly computed tables, Kremer concludes that this astrologer was not interested in collecting well defined 'works' by known authors; rather, he filled his toolbox with miscellaneous tables that he used to cast horoscopes and construct annual astrological calendars.

Alexandre Tur finds another toolbox in a quite different codicological format, a bat-book almanac now held at the Bibliothèque nationale de France. Recently profiled by J. P. Gumbert, who catalogued about sixty known exemplars dating from the thirteenth through sixteenth centuries, these small books contain up to twenty leaves, folded down to a hand-sized package and placed in a sheath designed to be hung from the owner's belt.[7] Tur discovers that the Paris bat-book, dated to 1456 and signed by an otherwise unattested 'frater Paulus de Kignin', contains material from John of Gmunden's widely distributed *Kalendarium*, composed twenty years earlier in Vienna, and was probably revised for liturgical use in a Franciscan community in Northern Italy. Extremely portable, this sanctorale and compendium of official Franciscan liturgical material took Alfonsine astronomy into an unusual context. Tur concludes, however, that as the sole surviving exemplar of John of Gmunden's calendar in this format, the Paris bat-book probably

6 Cf. Constant Mews and John N. Crossley (eds), *Communities of Learning: Networks and the Shaping of Intellectual Identity in Europe, 1100–1500* (Turnhout: Brepols, 2011).

7 J.P. Gumbert, *Bat Books: A Catalogue of Folded Manuscripts Containing Almanacs or Other Texts* (Turnhout: Brepols, 2016).

represents an idiosyncratic prototype for a Franciscan convent and not a serial production of a format that was not preserved.

Eric Ramírez-Weaver considers the cultural and art historical significance of Alfonsine astronomy at the Prague court of Wenceslaus IV, notably reviewing the visual programmes (frontispieces and illuminated initials) in three luxurious manuscripts prepared around 1400. Even as Wenceslaus's political fortunes were declining, his courtiers designed books whose contents would have emphasized links between the King and Alfonso X of Castile, portraying both courts as centres of erudition and astral sophistication. This essay argues that the Alfonsine Tables in Prague served not merely computational but also cultural and political purposes. And they might have offered their embattled patron, the King, a curriculum of cosmic harmony as 'a model for earthly peace'.[8]

By considering 'books' rather than simply 'texts', the authors of Part 1 have opened new vistas to the history of Alfonsine astronomy. It is true that some of its texts were authored by Paris masters or were curated by fellows of Merton College for study by Oxford scholars; but these materials also circulated widely beyond the university milieu. Alfonsine codices were compiled by practicing astrologers seeking patrons, reformatted for liturgical use in monastic houses, decorated and adorned to encourage a beleaguered and inept king. Reports and rumours of the Castilian Alfonsine Tables, initially produced and copied in King Alfonso X's scriptorium, continued into the nineteenth century, even if no physical codices have been found. The Alfonsine Tables, as shown by the authors of Part 1, circulated both as books and as imaginaries.

Part 2: Authors and texts in various milieus

The essays of Part 2 turn from the particular codex to the individual work or author. These contributions ask how particular works have been preserved in surviving manuscript witnesses and how broader manuscript cultures shaped the diffusion, over two centuries, of Alfonsine astronomy across Europe. In some of these essays, the authors show how the manuscript witnesses make it difficult to define boundaries for a given work. Other essays examine how the preparation of critical editions can reveal particular scribal practices. Still others investigate how reputations constructed for given authors affect textual attribution or decisions about what material to bind into a single codex.

Although Part 2 retains a focus on the manuscript level, its chapters consider what the manuscripts can tell us about the identity of 'Alfonsine' works for the historical participants who copied or collected the materials. Additionally, they ask how the agency of authorship was distributed among scribes, compilers, commentators, patrons, 'actual' authors, and the *auctoritas* or attributed intellectual creators. Indeed, by following the manuscripts, the ALFA Project is problematizing the concept of a 'critical edition' for certain Alfonsine works, especially the Parisian Alfonsine Tables. Alfonsine astronomers and their scribes combined different canons with different sets of tables; they rearranged the order of

8 Eric Ramírez-Weaver, 'Bohemian King Wenceslas IV's Copy of the Alfonsine Tables and Their Place Within his Astronomical and Astrological Corpus," in *Alfonsine Astronomy: The Written Record*, ed. by Richard L. Kremer, Matthieu Husson and José Chabás (Turnhout: Brepols, 2022), pp. 199-240 (p. 234).

chapters within canons and the order of tables within sets of tables. Even the appearance of printed editions in 1483 and 1492 did not standardize a single version of the Parisian Alfonsine Tables. Such are the issues raised by the essays of Part 2.

José Chabás and Marie-Madeleine Saby consider the challenge of editing the *Tables of 1322* by John of Lignères, a work that is not found, in its entirety, in any given manuscript witness. As a member of the group of Parisian astronomers who in the 1320s reworked Castilian material into what we now call the Parisian Alfonsine Tables, John of Lignères assembled a set of thirty-two tables (mostly for spherical astronomy, eclipses and limited planetary motions) that illustrate the transition from the Toledan Tables of eleventh-century al-Andalus to Alfonsine astronomy. Chabás and Saby discuss the criteria they developed for selecting, from the more than 30 manuscripts containing related material, five witnesses for their forthcoming critical edition. These include both external (date and milieu of production) and internal (legibility, composition, and layout) factors. Their goal is to document one of the sets of astronomical tables most broadly diffused during the Alfonsine era.

Alena Hadravová and Petr Hadrava offer a first edition of one of John of Lignères' canons, the *Quia ad inveniendum loca planetarum*, that is, instructions for computing planetary longitudes and possibilities for eclipses with the Parisian Alfonsine Tables. Although relatively short (usually filling only a few folios), the *Quia* is quite variable as recorded in the extant manuscripts, a finding that Hadravová and Hadrava explain by suggesting that scribes may have struggled to interpret and formulate these canons, which are among the earliest of Latin Alfonsine astronomy. They describe the ten manuscripts, dating from the mid-fourteenth through the mid-fifteenth centuries, collated for the edition. They also deploy a statistical method of binary correlation of variant readings to create a computer-aided *stemma codicum* of these witnesses. An English translation follows the edited version of John's Latin text.

José Chabás examines several short texts and tables that he recently found in Madrid and Vatican manuscripts. A *Canon supra kalendarium magistri Johannes de Lineriis* and a table of mean syzygy times from 1321–96 is uniquely preserved in a fourteenth-century Madrid manuscript. By comparing these times with those found in other syzygy tables more firmly attributed to John of Lignères and to John of Murs, another early Parisian Alfonsine astronomer, Chabás concludes that the attribution of the Madrid manuscript to John of Lignères can be accepted. In two Vatican manuscripts, however, Chabás found another text and several tables attributed to John of Lignères. Although the tabular material is computed from the Parisian Alfonsine Tables, particularities in the meridians and the twenty-eight-year intervals found in the tables convince Chabás that these tables cannot have been authored by John of Lignères. Rather, the attribution to John of Lignères reveals the authority that this name had achieved a century after his death.

Matthieu Husson considers the authority of John of Lignères from a different angle, asking how another set of tables, firmly attributed to him, was copied into seven manuscripts over a period ranging from the mid-fourteenth to the late-fifteenth century. John's *Tabule magne* are comprised of a canon of eleven sections and eleven individual tables. Coining the phrase 'work cohesion', Husson asks how these twenty-two parts 'stuck together' or were rearranged, abridged, or reconfigured in the manuscript witnesses. He finds that most of the witnesses contain 'procedural gaps', where missing canon sections would prevent users, strictly following the textual instructions, from completing tasks

described by subsequent sections. Some canon sections do not relate to any specific table and thus were less 'sticky'. Likewise, the twenty manuscripts bearing the tables often blend in material from John's *Tables of 1322*; canons, however, generally do not blend material from other canons. Nonetheless, Husson concludes that for Alfonsine scribes, the *Tabule magne* did not exhibit strong cohesion and did not circulate as tightly organized sets of working instructions. Instead, the manuscripts reveal the pragmatic variability of scribes as they redacted the astronomical canons and tables they copied.

Laure Miolo introduces John of Genoa, a Parisian astronomer of the 1330s who authored four short works related to eclipse calculations. She offers the first biographical sketch of this little-known figure, defines and dates his works, and identifies more than thirty manuscripts that witness this material. Most copied was his table of lunar and solar velocities and apparent radii of these bodies during eclipses. The accompanying canon is known in fewer manuscripts, suggesting a low level of 'cohesion' (Husson's term) between the tables and canon. John's more theoretical *Canones eclipsium* is known in only seven manuscripts of diverse provenance (England, Italy, Germany, and France). His final work, a didactic calculation of the solar eclipse of 1337, is found in only three manuscripts. Miolo's study thus provides yet another example of Alfonsine astronomers copying and preserving pragmatic computational tools more frequently than they did theoretical or didactic works.

Glen van Brummelen also considers the opus of a single author, in this case the mid-fifteenth-century Italian mathematician, Giovanni Bianchini, some of whose work would be printed in the 1490s. Although dozens of manuscripts are witnesses to Bianchini's five major texts, van Brummelen lists eight codices that exclusively contain his works. Several of these are luxurious, illuminated presentation codices, written by a single professional hand. Others are copied in various hands, sometimes quite casually, in codices overflowing with marginal notes that undoubtedly served as toolboxes for working astronomers/astrologers. These eight manuscripts, all produced in Italy during the 1460s, provide another example of 'cohesion' among texts that van Brummelen explains by suggesting that Bianchini's mathematical innovations required readers to move among his various works. In any case, the works of no other author during the Alfonsine period exhibit as much cohesion as do Bianchini's.

Like those in Part 1, the essays in Part 2 seek to understand individual works, authors, and their *oeuvres* by paying close attention to the manuscript witnesses and the physical evidence they contain. The generally unknown scribes who copied the texts, the patrons or practitioners who selected what to assemble and bind, and the later readers who annotated the folios or preserved the codices, all helped define what we now call the 'Alfonsine corpus'. The diffusion of Alfonsine material across Europe over the course of three centuries was not simply a matter of discrete works being identically copied and carried from one place to another. Instead, the evolution of manuscript cultures and the needs of Alfonsine practitioners shaped and reconfigured the material as it moved through time and space. By following these processes, the essays of this volume begin to question some of the fundamental historiographical notions of 'author', 'work', and 'edition' long deployed by historians of the medieval sciences.

Finally, the essays of this volume begin to illustrate how Alfonsine astronomy developed a life beyond the medieval university and Latin learning. Unlike many popular texts

taught at university (e.g. Euclid's *Elements*, Sacrobosco's *Sphaera*, Aristotle's *De caelo*, or, later, Peurbach's *Theoricae novae planetarum*), the works of Alfonsine astronomy did not become 'scholasticized' or surrounded by commentaries and super-commentaries, questions, or disputations. Few Alfonsine texts ever became prescribed within official university curricula. Instead, the manuscript witnesses to Alfonsine works show less structured, more modular and flexible textual traditions, with individual codices tuned to the singular needs of their compilers and structured as composite manuscripts. It is certainly true that, during the first half of the fourteenth century, Paris and Oxford were decisive milieus in which the Parisian Alfonsine Tables and other important Alfonsine works were compiled. Moreover, in the fifteenth century, universities in Cracow and Vienna encouraged significant astronomical activity. Yet the courts of Castile, France (King Charles V), and Bohemia (King Wenceslas) also nourished astronomical activity, as did Holy Roman Emperors Frederick III and Maximilian I in Innsbruck. Religious orders, at times, also provided a context for the collection and compilation of Alfonsine materials. Likewise, noble families, such as the prominent d'Este of Ferrara, patronized important Alfonsine astronomers. Indeed, many 'working professionals', be they physicians, surgeons, astrologers, or calendar makers, required astronomical tables to cast the horoscopes they interpreted for their patrons. Following the Alfonsine manuscripts takes us beyond the confines of the universities.

In a time of crisis and fragmentation for late-medieval European society (plague, famine, depopulation, war, papal contestation, Hussite 'heresies', the 'fall' of Constantinople, etc.), Alfonsine astronomers assembled tools—composite manuscripts bearing modular works—that seem to reflect the fluidity of the social worlds in which they lived. Yet those manuscripts also offered them access to the reassuring, cultural presence of a stable, predictable, and mathematically describable view of the cosmos.

Digital tools and the written record

The last essay in this volume offers a self-reflexive analysis of how the tools of digital humanities have shaped collaborative researches within the ALFA Project. **Gala Topalian and Matthieu Husson** discuss the epistemic and methodological choices required to move from 'documents' (medieval manuscripts) to 'data' (digital artefacts) that can be processed, interrogated, and published for wider access. A digital survey has been constructed to curate information about the 390 discrete Alfonsine works found in 900 manuscripts and dozens of early printed editions. A new digital tool has been developed to store digital representations of astronomical tables and to facilitate their quantitative analysis, description, and critical edition. A text-oriented database based on TEI/XML technology will enable finer grained and more flexible modelling of a select number of manuscript witnesses. Formalizing these three ways of describing sources, Topalian and Husson conclude, has standardized vocabulary, clarified understandings of the objects under analysis, and enriched the research questions being explored by the ALFA team.

Bibliography

Benjamin, Francis S., Jr., and G. J. Toomer, *Campanus of Novara and Medieval Planetary Theory:* Theorica Planetarum (Madison: University of Wisconsin Press, 1971).

Chabás, José, *Computational Astronomy in the Middle Ages: Sets of Astronomical Tables* (Madrid: Consejo Superior de Investigaciones Científicas, 2019).

———, and Bernard R. Goldstein, *The Alfonsine Tables of Toledo* (Dordrecht: Kluwer, 2003).

———, and ———, *The Astronomical Tables of Giovanni Bianchini* (Leiden: Brill, 2009).

———, and ———, *A Survey of European Astronomical Tables in the Middle Ages* (Leiden: Brill, 2012).

———, and ———, 'Computing Planetary Positions: User-Friendliness and the Alfonsine Corpus', *Journal for the History of Astronomy*, 44(2013), 257–76.

———, and ———, *Essays on Medieval Computational Astronomy* (Leiden: Brill, 2015).

Comes, Mercè, Roser Puig, and Julio Samsó (eds), *De Astronomia alphonsi regis* (Barcelona: Universidad de Barcelona, 1987).

Dalen, Benno van, 'A New Survey of Islamic Astronomical Handbooks with Descriptions of More Than 200 Arabic and Persian Zijes' (unpublished manuscript, 2007).

———, *Islamic Astronomical Tables: Mathematical Analysis and Historical Investigation* (Farnham: Ashgate, 2013).

Goldstein, Bernard R, *The Astronomical Tables of Levi Ben Gerson* (New Haven: Archon Books, 1974).

Gumbert, J. P., *Bat Books: A Catalogue of Folded Manuscripts Containing Almanacs or Other Texts* (Turnhout: Brepols, 2016).

Houzeau, J. C. and A. Lancaster, *Bibliographie générale de l'astronomie,* 2 vols, new ed. (Brussels: Xavier Havermans, 1964).

Husson, Matthieu, Clemency Montelle, and Benno van Dalen (eds), *Editing and Analyzing Astronomical Tables: Towards a Digital Information System for the History of Astral Sciences* (Turnhout: Brepols, 2022).

Kennedy, E. S., 'A Survey of Islamic Astronomical Tables', *Transactions of the American Philosophical Society*, N. S. 46 (1956), 123–77.

King, David A., Julio Samsó, and Bernard R. Goldstein, 'Astronomical Handbooks and Tables from the Islamic World (750–1900): An Interim Report', *Suhayl* 2 (2001), 9–105.

Mews, Constant, and John N. Crossley (eds), *Communities of Learning: Networks and the Shaping of Intellectual Identity in Europe, 1100–1500* (Turnhout: Brepols, 2011).

Montelle, Clemency, and Kim Plofker, *Sanskrit Astronomical Tables* (Cham: Springer, 2018).

North, J. D., '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.

Ossendrijver, Mathieu, *Babylonian Mathematical Astronomy: Procedure Texts* (New York: Springer, 2012).

Pedersen, Fritz S, *The Toledan Tables: A Review of the Manuscripts and the Textual Versions with an Edition* (Copenhagen: C. A. Reitzels Forlag, 2002).

Pedersen, Olaf, *A Survey of the Almagest, with Annotation and New Commentary by Alexander Jones* (Berlin: Springer, 2011).

Porres de Mateo, Beatriz, 'Les Tables astronomiques de Jean de Gmunden: Édition et étude comparative', unpublished PhD thesis, Paris: École Pratique des Hautes Études, 2003.

Poulle, Emmanuel, *Les Tables alphonsines avec les canons de Jean de Saxe: Édition, traduction et commentaire* (Paris: Éditions du centre national de la recherche scientifique, 1984).

Robson, Eleanor, 'Reading the Libraries of Assyria and Babylonia', in *Ancient Libraries*, ed. Jason König, Katerina Oikonomopolou, and Greg Woolf (Cambridge: Cambridge University Press, 2013), pp. 38–56.

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

Schum, Wilhelm, *Beschreibendes Verzeichniss der amplonianischen Handschriftensammlung zu Erfurt* (Berlin: Weidmannsche Buchhandlung, 1887).

Sivin, Nathan, *Granting the Seasons: The Chinese Astronomical Reform of 1280, with a Study of Its Many Dimensions and a Translation of Its Records* (New York: Springer, 2009).

Thorndike, Lynn, and Pearl Kibre, *Catalogue of Incipits of Mediaeval Scientific Writings*, rev. and augmented ed. (Cambridge: Mediaeval Academy of America, 1963).

Toomer, G. J, 'A Survey of the Toledan Tables', *Osiris* 15 (1968), 5–174.

Zinner, Ernst, *Verzeichnis der astronomischen Handschriften des deutschen Kulturgebietes* (Munich: Beck, 1925).

———, *Geschichte und Bibliographie der astronomischen Literatur in Deutschland zur Zeit der Renaissance,* 2d ed. (Stuttgart: Hiersemann, 1964).