Chapter 8
Oronce Fine and Sacrobosco: From the Edition of the *Tractatus de sphaera* (1516) to the *Cosmographia* (1532)

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Abstract This paper considers the contribution of the French mathematician Oronce Fine to the diffusion and transformation of Johannes de Sacrobosco's *Tractatus de sphaera* by considering his 1516 edition of the *Sphaera* and his *Cosmographia, sive sphaera mundi* (in *Protomathesis*, 1532). The article first describes Fine's life and career, as well as his work as editor of the *Sphaera*. In a second part, it considers what Fine, in the *Cosmographia*, has drawn and left aside from the *Sphaera*, revealing the consequent transformations to the teaching of Sacrobosco's theory of the sphere and its adaptation to the cultural and intellectual environment in which Fine evolved. A last part considers the treatment, in the *Cosmographia*, of the cosmological representations transmitted by Sacrobosco and by subsequent interpreters of Ptolemaic astronomy concerning the number of celestial spheres and its relation to judicial astrology.

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1 Introduction[1]

Oronce Fine or Finé[2] (1494–1555), a French mathematician from the Dauphiné, is chiefly known to historians of science for having been the first to teach mathematics as a royal lecturer within the institution founded by François I in March 1530,[3] but also for his work as a cartographer,[4] as a designer and maker of mathematical instruments,[5] as well as an engraver and an editor of scientific books.[6]

If it should be admitted that Fine played an important role in the development of mathematics in sixteenth-century France, it is not primarily by the content of his works or of his teaching, which historians of mathematics have not regarded as significant to the advancement of the mathematics of his time (Ross 1975; Poulle 1978)[7] and which was criticized in Fine's lifetime by Pedro Nuñez (1502–1578) and Jean Borrel (Johannes Buteus) (1492–1564/72) in books aimed to expose the mistakes contained in his treatises (Nuñez 1546; Borrel 1554,[8] 1559).[9] It is rather

[1] The author would like to thank Roberto de Andrade Martins, Peter Barker, Jamie Brannon, Marius Buning, Kathleen Crowther, Charlotte Girout, Thomas Horst, Tayra Lanuza Navarro, Elio Nenci, Richard Oosterhoff, Isabelle Pantin, and Matteo Valleriani, for the insightful comments and exchanges on the theses of this paper.

[2] The issue whether the last syllable of Fine's name should or should not be accentuated is often discussed by his biographers (Rochas 1856–1860, I, 384; Gallois 1918, 1–25; Ross 1971, 8–9; Poulle 1978; Dupèbe 1999, II, 519; Axworthy 2016, 7). The main difficulty with regards to this question is that the Latin spelling of Fine's name is not fixed, not even in the manuscripts. While some French authors contemporary to Fine place an accent on the final syllable (Dupèbe 1999, II, 519), Fine's friend, Antoine Mizauld made "Fine" rhyme with "doctrine." Moreover, most historians of the Dauphiné, where Fine's family finds its origins, agree on the fact that the last syllable should not be accentuated, at least in its written form. Since this issue remains to be discussed, we have chosen to use here the non-accentuated form, which allows more flexibility.

[3] On Fine's role as royal lecturer in mathematics, see (Lefranc 1893, 120, 131, 178, 394; Margolin 1976; Tuilier 2006a, b; Pantin 2006; Dhombres 2006; Pantin 2009a; Axworthy 2016, 16–19).

[4] On Fine's cartographical work, see (Gallois 1890, 38–54, 1918, 1935; Langlois 1922; Bataillon 1951; Kish 1965; Dainville 1970; Karrow 1993, 68–90; Conley 1996, 115–132; Lestringant and Pelletier 2007; Brioist 2009b).

[5] On Fine's work on mathematical instruments, see (Destombe 1951; Hillard and Poulle 1971; Eagleton 2006, 2009; Turner 2009).

[6] On Fine's work as an editor and engraver, see (Johnson 1928; Brun 1934, 1966, 1969, 43–48; Ross 1971, 32–58; Margolin 1976; Conley 1996, 91–115; Dupèbe 1999, II, 523–24; Pantin 2009b, 2010, 2012, 2013a; Oosterhoff 2014, 2016, 2017).

[7] This is in particular how E. Poulle (Poulle 1978) described Fine's mathematical work: "Fine's scientific work may be briefly characterized as encyclopedic, elementary, and unoriginal. It appears that the goal of his publications, which ranged in subject from astronomy to instrumental music, was to popularize the university science that he himself had been taught."

[8] "Confutatio quadraturae circuli ab Orontio Finaeo factae."

[9] On Fine's mathematical mistakes and their public denunciations, in particular by Nuñez, see (Baldi 1998, 442–55; Ross 1971, 259–66; Clagett 1978, 1176–78 and 1209–24; Leitão 2009; Almeida 2017).

through his project to promote mathematical teaching in France,[10] a project he carried out—besides his life-long career as a royal lecturer in mathematics—by writing and publishing a substantial number of mathematical treatises, through which he contributed to the dissemination and expansion of the mathematical culture of his time[11] in the continuity of the endeavor led in this direction by Jacques Lefèvre d'Étaples (ca. 1450–1536) (Chap. 2), Pedro Sanchez Ciruelo (1470–1548) (Chap. 3), and their disciples[12] in Paris from the end of the fifteenth century on, as well as by assiduously calling upon the perfection and value of mathematics, as he did in particular in his *Epistre exhortative touchant la perfection et commodite des ars liberaulx mathematiques* (Fine 1531a).[13]

François I founded the institution of the royal lecturers on the suggestion of his librarian Guillaume Budé (1467–1540), in order to create a college where humanists would teach subjects such as Greek and Hebrew which were neglected by the university curriculum, but which were considered necessary to the study and interpretation of ancient pagan and Christian authors.[14] The foundation of a chair of mathematics shortly after the creation of the first royal lectureships in Greek and Hebrew[15] indicates that the teaching of mathematics provided at the University of Paris was judged insufficient, in spite of the efforts made in the previous decades by the circles of Lefèvre and Ciruelo to change this situation.[16] This is confirmed by the discourse held by Fine and by his successor Petrus Ramus (1515–1572) on the

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[10] On Fine's role in the development of mathematical teaching in sixteenth-century France, see (Ross 1971, 23–35; Margolin 1976; Tuilier 2006b; Pantin 2009a; Axworthy 2016, 27–37).

[11] Bibliographical lists of Fine's works are proposed in (Ross 1971, 398–449; Hillard and Poulle 1971; Ross 1974; Pantin 2013a; Axworthy 2016, 407–19).

[12] On these authors and on their role in the diffusion of mathematics in the Parisian academic sphere, see (Rey Pastor 1934; Ross 1971, 11–15; Margolin 1976; Pantin 2009a, 2013a; Oosterhoff 2015, 2016, 2018) (Chaps. 2 and 3).

[13] Fine wrote this versified eulogy of mathematics, addressed to François I, either before or shortly after his nomination as a royal lecturer around 1530 (Ross 1971, 21; Margolin 1976; Pantin 2009a, 2010; Axworthy 2016, 18).

[14] The first royal lectureships were dedicated to Greek and Hebrew and were attributed to Pierre Danès and Jacques Toussain for Greek and to François Vatable and Agathius Guidacerius for Hebrew. On the creation of these lectureships and on their first appointees, see (Irigoin 2006; Kessler-Mesguich 2006; Tuilier 2006a). Another institution which was oriented towards the pedagogical needs of humanists and which was founded in France in the same period is the Collège de Guyenne, established in Bordeaux in 1533.

[15] On the date of creation of the first royal lectureships, at least on the dates of the first lessons provided in this framework, see (Lefranc 1893, 109; Ross 1971, 21; Tuilier 2006a). On the date of foundation of the first royal chair of mathematics in particular, see (Lefranc 1893, 394; Hillard et al. 1971; Tuilier 2006a, b; Pantin 2009a; Axworthy 2016, 17–18).

[16] On the teaching of mathematics at the University of Paris at the beginning of the sixteenth century, see (Margolin 1976; Tuilier 2006b; Pantin 2009a; Cifoletti 2009; Oosterhoff 2018, 78–79).

ignorance of the students and masters of the Parisian Faculty of the Arts in mathematics (Dupèbe 1999, II, 523; Tuilier 2006a; Pantin 2006, 2009a; Oosterhoff 2015).[17]

As the first royal lecturer in mathematics, Fine's main assignment was to offer greater visibility to the mathematical arts in France and to reform the traditional mathematical curriculum by introducing, in addition to the mathematical content generally taught within the universities (Boethian theories of numbers and of consonances, Euclidean plane geometry, and Ptolemaic geocentric astronomy),[18] more practical branches of mathematics, through which the utility of mathematics would be more easily displayed, both for the disciplines taught in the higher faculties (medicine, law, and theology) and for the moral and material aspects of human life.

Fine's mathematical teaching program as a royal lecturer was made public through the *Protomathesis,*[19] a quadripartite mathematical compendium published in 1532, shortly after his assignment to this function. This monumental work provided a teaching on practical arithmetic (*De arithmetica practica libri IIII*), on theoretical and practical geometry (*De geometria libri II*), on cosmography (*De Cosmographia, sive sphaera mundi libri V*), as well as on gnomonics (or the art of sundials) (*De solaribus horologiis et quadrantibus libri IIII*).[20] Mixing theoretical

[17] (Euclid 1536, sig. ∗2r): "Dum celebres illas et fidissimas artes, quae solae Mathematicae, hoc est, disciplinae merverunt adpellari: raros admodùm offendi (etiam in numerosa auditorum multitudine) qui satis fido ac liberali animo, tam utile ac jucundum philosophandi genus, à limine (ut aiunt) salutare, ne dicam ad illius penetralia, penitioràque secreta, pervenire dignarentur…. Qui enim ad lauream adspirant philosophicam, jurejurando profitentur arctissimo, sese praenominatos Euclidis libros audivisse. An verò illius elementa, multis ab hinc annis, usque ad nostra viderint, ne dicam intellexerint, tempora (paucis forsitam exceptis, quos aequus amavit Juppiter) non ausim honestè confiteri." See also Ramus (Ramus and Talon 1599, 376): "Mathematicas artes adhuc in publicis Philosophici studii legibus et institutis nullum honorem, nullum separatim locum habuere, ut Mathematum prorsus ignarus, tamen legibus Parisiensis Academi, philosophicam lauream consequatur." (Pantin 2006; Axworthy 2016, 13–14).

[18] On the mathematical textbooks read at the faculty of the arts at the beginning of the sixteenth century, see (Chap. 5).

[19] This title, which corresponds to the Latin transliteration of a Greek term composed of the suffix *προτο-* (first) and of the substantive *μάθησις* (teaching, knowledge), literally means "first teaching" and intends to assert thereby the propaedeutic function of mathematics (Axworthy 2009, 2016, 127–43).

[20] Although the *Protomathesis* displays a quadripartite structure, it does not perfectly mirror the structure of the quadrivium since Fine then replaced music (or the theory of consonances) with gnomonics. Fine did, however, contribute to the diffusion of the Boethian theory of consonances through the publication of the *Epithoma musice instrumentalis ad omnimodam Hemispherii seu Luthine et theoricam et practicam* in 1530 (Fine 1530), where this theory of harmony is also taught along its applications to the reading, composing, and playing of lute pieces. Thus, the fact that the *Protomathesis* does not include any treatise on music could be due to the fact that Fine had already published, or was about to publish, the *Epithoma musice instrumentalis* when he was assigned to the position of royal lecturer in mathematics and therefore did not consider it necessary to publish another treatise on music, or to publish again the text of the *Epithoma* within his mathematical compendium. Indeed, as indicated by the date of 1530 on the title pages of the *Geometria* and of the *Cosmographia* (Fine 1532, 49r, 101r), the publication process of the *Protomathesis* started at the latest in 1530. Notwithstanding, the fact that, in the *Protomathesis*, music is in a sense "replaced" by gnomonics proposes a representation of mathematics which differs from the tradi-

and practical knowledge (from Euclidean geometry and the theory of the sphere to the construction and use of surveying instruments and sundials),[21] the publication of the *Protomathesis* was important for the new image it provided of mathematics, in France and beyond.[22] As shown by Isabelle Pantin, the publication of this work, as well as of the many separate and successive editions of the different treatises that compose it,[23] also helped shape the Parisian style of printed scientific books (Pantin 2010, 2013a, Oosterhoff 2016).[24]

Astronomy held a central role in Fine's mathematical work. This is manifested by the dominant number of treatises on astronomy, astrology and astronomical instruments, amid the numerous works he wrote, published and edited.[25] Among the latter, the two first books on which he worked as an editor were the *Theorica planetarum* of Georg Peurbach (1423–1461), which was published in Paris in 1515 (Pantin 2009b, 2012, 2013a),[26] as he was studying at the Collège de Navarre, and the *Tractatus de sphaera* of Johannes Sacrobosco (died ca. 1256)[27] in 1516 (Pantin, 2009b, 2010, 2013a; Pettegree and Walsby 2012, 1020–21).

A central role was also attributed to astronomy within Fine's mathematical teaching program, since the *Cosmographia, sive mundi sphaera* (of which four out of five books deal with spherical astronomy) stands, among the different treatises that compose the *Protomathesis*, simultaneously as the culminating point of the quadrivium,[28]

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tional model drawn from the model of the quadrivium (as represented, for example, by the mathematical section of the *Margarita philosophica* of Gregor Reisch, which Fine worked to edit around 1523) and which aims to promote practical mathematics.

[21] On Fine's practical mathematics, see (Métin 2004; Guyot and Métin 2004; Dhombres 2006; Eagleton 2009; Dupré 2009; Brioist 2009a; Mosley 2009; Pantin 2006, 2009a, 2010; Oosterhoff 2014, 2016; Axworthy 2016, 249–300).

[22] This work was translated into Italian (along with a treatise on burning mirrors, published in 1551) by Cosimo Bartoli in 1587 as *Opere di Orontio Fineo del Delfinato divise in cinque Parti*.

[23] The *Arithmetica practica* was reprinted in 1535, 1542, 1544 and 1555; the second book of the *Geometria* was reprinted in 1544, 1556, 1558, 1584, 1586; the *Cosmographia* was reprinted twice in 1542 (unabridged and abridged versions), in 1551, 1552, 1555 and, in French, in 1551 and 1552. See (Fine 1535, 1542a, 1544a), for the bibliographical references of these reprints.

[24] On the Parisian context of scientific book printing, see also (Crowther et al. 2015; Valleriani 2017).

[25] (Peurbach and Fine 1515; Sacrobosco and Fine 1516; Ricci and Fine 1521; Sacrobosco et al. 1521; Fine 1526, 1527, 1528, 1529, 1532, 1543a, b, 1544b, 1545, 1553a, b, c, 1557; Borrhaus 1551; Mizauld 1552). To this, we could add (Reisch and Fine 1535). See also the lists of Fine's works compiled in (Ross 1971, 398–449; Hillard and Poulle 1971; Pantin 2013a; Axworthy 2016, 407–11).

[26] Fine published in 1525 a revised version of his edition of Peurbach's *Theorica* (Peurbach and Fine 1525), which only featured the original text (without the commentary of Francesco Capuano de Manfredonia (fl. 15th cent.) (Peurbach 1495), with which it was published in 1515), but with a clearer layout and with the inclusion of *marginalia*, using for Peurbach's text some of the figures initially drawn for the commentaries (Pantin 2013a). He also published in 1528 a treatise in French entitled *La Theorique des cielz, mouvemens, et termes practiques des sept planetes* (Fine 1528), which may be regarded as an adaptation or a paraphrase of Peurbach's *Theorica planetarum*.

[27] On the life and works of Sacrobosco, see (Pedersen 1985).

[28] On the traditional order of teaching of the various parts of the quadrivium and its reception by Fine, see (Axworthy 2016, 50–53).

following arithmetic and geometry (music having been left aside), and as the condition of the application of mathematics to a more practical and specialized type of knowledge, then mainly represented by cartography (through the fifth book of the *Cosmographia*) and gnomonics (the last part of the *Protomathesis*).

The importance of astronomy in Fine's mathematical work is also displayed by the manner in which he represented himself in the frontispieces of his editions and treatises pertaining to astronomy,[29] depicting himself in the place of the astronomer, where the figure of Ptolemy (ca. 85–ca. 165) was often positioned in the frontispieces of late fifteenth-century astronomical textbooks—that is, beneath the sphere of the universe (sometimes represented as an armillary sphere), holding a book (open or closed) and/or an astronomical instrument, the muse Urania placed besides him (Pantin 1993; Conley 1996, 98–115; Pantin 2009b; Barker and Crowther 2013).[30] Although he perpetuated in this way a preexisting visual tradition, it is notable (as Pantin points out) that Fine, who usually engraved the visual material contained in his editions and treatises, did not produce comparable illustrations for his works on other mathematical disciplines (Pantin 2009b).[31] It also seems significant that the astronomical frontispiece which is associated with the first edition of his *Cosmographia*—where Fine represented himself sitting under a celestial sphere while holding both an astronomical instrument and an open book—was used twice in the *Protomathesis*, once at the head of the entire compendium (after the general index) and once at the head of the *Cosmographia*, though with two different epigrams: one applied to mathematics in general, and more specifically to arithmetic and to the role of the knowledge of numbers and measure for the knowledge of the creation and of its components,[32] and the second applied to astronomy, commending the usefulness of the science of stars for the contemplation of the divine order.[33] The use of this frontispiece to introduce the whole compendium, along with the accompanying epigram explaining the importance of mathematics for the knowledge of the causes of the wordly substances, also confirms the central and overarching role of astronomy within the quadrivium according to Fine.

[29] An exception to this is his *Theorique des cielz* (Fine 1528), which was published anonymously and only reprinted with Fine's name postumously, that is in 1557, 1558, 1607, and 1619.

[30] On the intellectual filiation between Ptolemy and Fine, see (Pantin 1993, 2009b; Conley 1996, 98–114).

[31] Yet, such frontispieces existed for other mathematical disciplines in the contemporary literature, as in the *Margarita philosophica* of Gregor Reisch, which Fine edited.

[32] (Fine 1532, AA8v): "Cùm natura sagax numero mensùque crearit / Singula, ponderibus clauserit inde suis: / Non poteris rerum proprias discernere causas, / Ni teneas numeros, et geometra simul." The frame of the frontispiece features these verses: "Disce prius numeros tellurisque ordine mensus: nam facilem cura haec sternet ad alta viam." This epigram was taken up and slightly modified in ulterior versions of the *Arithmetica practica*. On the evolution of the epigram in this context, see (Pantin 2009b; Axworthy 2016, 54–56).

[33] (Fine 1532, 101v): "Florida divinae quisquis secreta mathesis / Scire cupis, facili mente fruare decet / Nam licet assiduo possis superare labore, / Mens generosa tamen plurima sola capit." In the frame, "Excute sollicito fragiles de pectore curas: et studeas superas arte subire domos." These verses were used again in the unabridged 1542 edition of the *Cosmographia*, but in the place of the epigram of the 1532 frontispieces.

Moreover, although Fine greatly emphasized the need to develop, in France, the teaching of all mathematical disciplines, theoretical and practical, he also regularly asserted in his prefaces the predominant importance of astronomy over the other parts of the quadrivium with respect to the primary purpose of mathematics according to the ancient model of education—that is, to open the path to wisdom and to the knowledge of the divine order that governs the universe, in conformity with Platonic epistemology (Barker and Crowther 2013; Axworthy 2016, 151–64).[34] He followed in this regard the discourse held by Johannes Regiomontanus (1436–1476) in the inaugural oration of his lessons at the University of Padua in 1464 (Pantin 2009a), where astronomy is described both as the crowning of the quadrivium and as the reason for which the other parts of mathematics should be studied.[35]

With respect to the scope of the present volume, the aim of this paper is to examine the significance and transformation of Sacrobosco's astronomical teaching, both in Fine's work as an editor of the *Tractatus de sphaera* and as the author of the *Protomathesis* and, more precisely, of the *Cosmographia, sive sphaera mundi.*[36] Following a brief biographical outline, I will first describe Fine's work for the 1516 edition of the *Sphaera* to examine afterwards how the *Cosmographia*, his major astronomical work, relates to the content of Sacrobosco's treatise. I will conclude this paper by considering Fine's conceptions (as they appear in the *Cosmographia*) on the cosmological representation transmitted by Sacrobosco and by subsequent interpretations of Ptolemaic astronomy concerning the number of celestial spheres, as an illustration of the uses and transformations of cosmological knowledge in the tradition of Sacrobosco's teaching of spherical astronomy.

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[34] On the propaedeutic role of mathematics according to Fine, see (Pantin 2009a; Axworthy 2009, 2016, 127–49). On the discussions prior to Fine concerning the relation of astronomy to mathematics in general, but also to the other parts of philosophy involved in the contemplation of the universe, see (Chaps. 2, 3 and 4,).

[35] (Regiomontanus 2008, 137): "Inter omnes autem hasce disciplinas astronomia instar margaritae non modo sorores suas, reliquas inquam scientias medias, verum etiam omnium disciplinarum matres geometriam et arithmeticam longe antecellit; cujus ortum prae vetustate nimia haud satis comperimus ita ut aeternam aut mundo concreatam non inique putaveris." (Fine 1542a, sig. ∗2r–v): "Quanquam enim ipsae Mathematicae, omne philosophandi genus adaperiant, et in universum cunctis opitulentur artibus: eò tamen omnes tendere videntur, ut Caeli suscipiendi peculiarem sortitae sint curam. Quam beatissimam contemplationem, Astronomiam vocant." (Fine 1551a, sig. aa2r–aa3v): "Ipsa autem caelestium rerum eruditio, earum disciplinarum beneficio comparatur, quae mathematicae nuncupantur: quarum videlicet essentialis puritas, fida atque inviolabilis certitudo, humana divinis, terrenave caelestibus vel facilè conciliat. Et proinde inter ispius mathematicae partes, ea longè praestantior esse videtur, quae Astronomia dicitur: utpote, in cujus gratiam caeterae omnes videntur excogitatae, et quae caelestia simul et terrestria ratiocinatur corpora." (Fine 1555, sig. 2v): "Omnis itaque philosophia, omnisque certa et inviolabilis doctrina, qualis est Mathematica, eò potissimùm tendere videtur, ut in veram caelestium rerum cognitionem mortales inducat."

[36] For this paper, I will mostly refer to the first edition of the *Cosmographia*, which was first printed 1530 (as indicated by the title page of this particular treatise) though it was published in 1532 with the other parts of the *Protomathesis*. Because the denomination *Cosmographia* comes in this edition before that of *Sphaera mundi*—this is not the case in the later editions—I will use the shortened title *Cosmographia*.

2 Fine's Life and Career

Fine was born in 1494 in Briançon to a family of high social rank, which constituted a stimulating environment for the development of scientific interests during the first years of his life (Thomé de Maisonneufve 1922; Thomé de Maisonneufve 1924, 5–10; Ross 1971, 8–11).[37] His grandfather and his father, Michel Fine (fl. 1474–1490) and François Fine (fl. 1494–1499), were both physicians (Wickerheimer 1979, 154, 553). The former wrote a treatise on the plague, whose posthumous publication Oronce contributed to in 1522 (Fine 1522; Dupèbe 1999, II, 521). The latter is said to have built an equatorium, which William Gilliszoon of Wissekerke (ca. 1444) described in his *Liber desideratus super celestium motuum indagatione sine calculo* (Wissekerke 1538, sig. A2r–v; Poulle 1961). When his father died, he was sent to Paris and entrusted to Antoine Silvestre, a family friend from Briançon who taught arts at the Collège de Montaigu and theology at the Collège de Navarre (Launoy 1677, 646–47; Élie 1951), where Fine studied. Fine obtained his Master of Arts in 1516 at the Collège de Navarre (Launoy 1677, 678), where he started the same year to teach mathematics both privately and publicly at least until 1527 (Dupèbe 1999, II, 533).[38] He began in parallel to study at the faculty of medicine, obtaining his bachelor's degree in 1522 (Concasty 1964, 50b, 54a–b; Dupèbe 1999, II, 526–27). From 1528 on, he taught mathematics at the Collège de Maître Gervais (Dupèbe 1999, II, 540–41; Boudet 2007; Pantin 2009a, 2013a).

François I's choice to assign Oronce Fine to the first royal chair of mathematics was likely influenced by the support Fine received from humanists close to the royal court (Dupèbe 1999, II, 530, 533, 538), as well as by his multifaceted mathematical activity in the years 1515–1530 (Pantin 2006, 2009a; Axworthy 2016, 14–17). These were the years during which he worked on his first editions and illustrations of mathematical and non-mathematical works (Peurbach and Fine 1515; Sacrobosco and Fine 1516; Le Huen 1517[39]; Bassolis and Fine 1517a, b; Martínez Silíceo and Fine 1519; Ricci and Fine 1521; Fine 1522; Reisch and Fine 1535)[40] and published under his name several mathematical treatises (mostly pertaining to astronomy) (Fine 1526, 1527, 1528, 1529, 1530), as well as a map of France (Fine 1525). He also practiced during this time as a court astrologer.[41]

[37] More generally, on Fine's life, education, and career, see (Thévet 1584, 564r–66v; Baldi 1998, 442–55; Thorndike 1941, 284–86; Escallier 1957; Ross 1971, 8–30; Poulle 1978; Aked 1990; Marr 2009; Pantin 2009b, 2013a; Oosterhoff 2016; Axworthy 2016, 12–22).

[38] J. Dupèbe (Dupèbe 1999, II, 522) surmises that he was teaching in 1515 at the Collège de Montaigu, when he edited Peurbach's *Theorica planetarum*.

[39] Fine engraved, for this work, a map of the Holy Land (Conley 1996, 91–98; Pantin 2009b).

[40] This edition of Reisch's *Margarita philosophica* was published in 1535 (Reisch and Fine 1535), but the date of 1523 at the end of the preface indicates that it had been prepared by Fine while he was teaching at the Collège de Navarre.

[41] According to certain historical accounts, Fine would have been imprisoned around the years 1524–1525 because of a horoscope that would have either been unfavorable to a member of the court, Louise de Savoie (Lefranc 1893, 178; Gallois 1918), or favorable to the Constable of Bourbon (Charles III of Bourbon), an enemy of the court (Destombes 1971). The first of these two

Fine remained a royal lecturer until his death in 1555. During the 25 years he taught mathematics in the name of the King of France, which would have represented an exceptionally long career for such a position at the time, he published many other treatises, among which several reprints of the first three parts of his *Protomathesis*, as well as new treatises dealing with astronomy and its applications (Fine 1543a, b, 1545, 1553a, b, 1557), geometry (Euclid 1536; Fine 1544b, 1556a, b) and the theory of burning mirrors (Fine 1551b).

Thanks to his high-quality editions, geographical maps, and mathematical treatises, Fine rapidly gained an international reputation, notably in Italy and in England (Johnson 1946; Heninger 1977a, b; Feingold 1984, 59, 116, 118; Tredwell 2005, 185; Eagleton 2009; Mosley 2009; Leitão 2009; Wagner 2010; Rampling 2012; Valleriani 2013, 76–77; Axworthy 2016, 22–27; Valleriani 2017, 430). The Italian translation of the *Protomathesis* by Cosimo Bartoli (1503–1572), published with the translation of the *De speculo ustorio* by Ercole Bottrigari (1531–1612) (Fine 1587) as well as the English translation of his *Canons des ephemerides* by Humphrey Baker (fl. 1562–1587) (Fine 1558), testify to the international and long-lasting influence of Fine's mathematical teaching throughout the sixteenth century. His *Cosmographia* notably appears in the *Bibliotheca selecta* compiled by the Jesuit Antonio Possevino among the sources relevant to the study of astronomy (Possevino 1593, 201; Margolin 1976; Mosley 2009). His astronomical and arithmetical works were included in the programs of the Jesuit College of Messina (Sasaki 2003, 21; Gatto 2006), of the University of Pisa (Schmitt 1974, 1975) (Chap. 10), of the University of Cambridge (Johnson 1946; Feingold 1984, 39), and also very likely of the Spanish University of Valencia (Navarro Brotóns 2006).[42] At the University of Oxford, the statutes of 1565 recommended astronomy lecturers to teach Fine's *Cosmographia* as a possible alternative to Sacrobosco's *Sphaera* (Goulding 2010, 88–89).

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hypotheses is founded on a letter (written in Lyon on the 3rd of November, 1526) by Heinrich-Cornelius Agrippa, who claimed that Fine had been imprisoned for having made an unfavorable horoscope to a member of the French court (in order to justify his reluctance to make prognostications to the French court while in Lyon). (Agrippa 1970, II, letter 62, book 4, 844): "Sed et nesciebam me praedariò astrologum conductum, quodque mihi, quod ars illa dictat, monendi dicendique jus relictum non esset, occurritque exemplò Orontius Parrhisiorum insignis mathematicus et astrologus, qui dum veriora, quàm poterat, vaticinaverat, iniquissima captivitate diutinè vexatus est: iamque aiebam apud me, quid, si reliqua misisses prognostica? proculdubio ex fumo in flammam te conjecisses." Yet, although it is generally admitted by historians that Fine spent some time in prison, the reason for this unfortunate event is not fully attested, as other sources suggest that it may have been because of his opposition to the Concordat (Boulay 1665–1673, 4, 965–66; Tuilier 2006a) or for having refused, as he worked on the fortifications of Milan, to submit himself to the aforementioned Constable of Bourbon, who would have had him arrested during the construction of a bridge on the Tessino (Escallier 1957, 6–7; Aked 1990). More generally, on this issue, see (Ross 1971, 386–97; Dupèbe 1999, II, 536–38).

[42] As indicated by Víctor Navarro Brotóns (Navarro Brotóns 2006), Jerónimo Muñoz, who studied in Valencia for his Bachelor of Arts, referred to Fine as "preceptor noster" in his *Astrologicarum et geographicarum institutionum libri sex* (Muñoz 2004, 68v).

3 Fine's Edition of Sacrobosco's *Sphaera* and It's Significance for His Pedagogical and Scientific Project

Sacrobosco's *Sphaera* was, as indicated above, the second treatise on which Fine worked as an editor. It was first published in 1516 in Paris by Regnault Chaudière (died 1554), when Fine was about twenty years old and was teaching at the Collège de Navarre.[43] As indicated by the title and the colophon, the work he performed for this edition of the *Sphaera* consisted in applying corrections, engraving woodblocks, and adding marginal indications.[44] In addition to his epigram to the reader, he included several liminary poems at the beginning and at the end of the book,[45] written by himself and by some of his colleagues or condisciples, such as the poet Hugues d'Ambert or Hugues de Colonges (fifteenth–sixteenth century), who was then addressing both Fine[46] and Fine's protector Antoine Silvestre,[47] and Nicolas Petit (1497–1532),[48] addressing Jean Fossier or Jean des Fosses (fifteenth–sixteenth century),[49] one of Fine's disciples (Dupèbe 1999, II, 526).[50] The engravings provided by Fine for this edition were mostly modeled on the figures found in the editions of Sacrobosco's *Sphaera* published in Venice from the end of the fifteenth century onwards (Cosgrove 2007; Pantin 2010) (Chap. 9),[51] though he integrated, for the representation of the motion of the sun, engravings he had produced for his

[43] This is indicated in the title of the epigram to the reader which prefaces his edition of Sacrobosco: (Sacrobosco and Fine 1516, sig. a1v): "Orontius Fine Briansonnianus: Ebredunensis Artium liberalium professor: Ad lectorem: Phaleuticum Epigramma."

[44] (Sacrobosco and Fine 1516, title page) *Mundialis sphere opusculum Joannis de sacro busto: nuper vigilantissime emendatum una cum figuris accommodatissimis: cumque marginariis annotatiunculis recenter adjectis* and (sig. d3v): "Explicit tractatus de sphera Johannis de sacro busco profundissimi Astronomi. Nuper vigilantissime per Magistrum Orontium Fine: emendatus: et ab eodem figuris accommodatissimis. Nec non et marginarijs annotatiunculis illustratus."

[45] (Sacrobosco and Fine 1516, sig. a1v): *Phaleuticum Epigramma* (epigram in phalecian verses), (Sacrobosco 1516, sig. a1v): *Saphicum* (saphic verse), (sig. d3v): *Epigramma Extemporeaneum* (improvised epigram); *Carmen Elegum* (elegiac verse), sig. d4r: *Endecasillabum* (hendecasyllabic verse). I would like to thank Alain Legros for the complementary indications he provided me on these verses.

[46] (Sacrobosco and Fine 1516, sig. d3v): "Magistri Hugonis Ambertani Eruditissimo artium doctori. Exactissimoque Astrosophie percunctatori Orontio Fine Epigramma Extemporeaneum."

[47] (Sacrobosco and Fine 1516, sig. d4r): "M. Hugonis ambertani celeberrimo bonarum literarum Magistro Anthonio silvestri preceptori observando. Endecasillabum."

[48] Nicolas Petit was a poet, rector of the Faculty of law of Poitiers and professor at the Parisian Collège de Montaigu, where Fine also taught.

[49] (Sacrobosco and Fine 1519, sig. d3v): "M. Nicolai Parvi Bellosanensis libri munere fugentis ad magistrum Johannem Fosserium virumundecunque doctissimum. Carmen Elegum."

[50] All three, and very likely also Fine himself, would have been disciples of Antoine Silvestre (Élie 1951).

[51] On the illustrations in the Venetian editions of Sacrobosco, see (Gingerich 1999; Cosgrove 2007; Barker and Crowther 2013; Oosterhoff 2015).

edition of Peurbach's *Theorica planetarum*.[52] This edition also contains a few tables: a table displaying the cosmic, chronic, and heliacal rising and setting of the signs;[53] a table for the rising and setting of the signs in the right sphere (indicating the durations of the rising and setting of each sign and the quantities of the corresponding arcs of equinoctial);[54] a table for the latitudes of the seven climates, coupled with a table indicating the duration of the longest artificial days for these latitudes.[55] The inclusion of these tables, though quite elementary, demonstrates Fine's will to add to the *Sphaera* complementary elements of a practical nature,[56] in line with the material added by Lefèvre d'Étaples in his 1495 commentary on Sacrobosco (Sacrobosco et al. 1495; Oosterhoff 2015) (Chap. 2). This also anticipated his later contribution to the diffusion and transformation of spherical astronomy in the tradition of Sacrobosco's *Sphaera* in the *Cosmographia*. The printed *marginalia* mark out the different topics dealt with by Sacrobosco, the authors referred to such as Virgil (Publius Vergilius Maro, 70–19 BCE), Ovid (Publius Ovidius Naso, 43 BCE–ca. 18), Lucan (Marcus Annaeus Lucanus, 39–65), al-Farghānī (Abū al-ʿAbbās Aḥmad ibn Muḥammad ibn Kathīr al-Farghānī, ca. 805–870), as well as the distinction and hierarchical status of the various arguments provided,[57] giving this edition the style and the structure of university textbooks while making the text easier to read and consult.[58] The large white spaces on the exterior margins also facilitated note-taking, as shown by extant exemplaries containing substantial hand-written marginal notes.[59]

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52 The two illustrations in (Sacrobosco and Fine 1516, sig. d1v) are drawn from (Peurbach and Fine 1515, 14r, 24v). On Fine's engravings for the 1515 edition of the *Theorica*, see (Pantin 2012).

53 (Sacrobosco and Fine 1516, sig. b4r): "Tabula ortus: et occasus cosmici et chronici 12 signorum. Ortus vero et occasus heliacus signorum per introitum solis in 12 signa sciri poterit."

54 (Sacrobosco and Fine 1516, sig. c1r): "Tabula ortus et occasus signorum in sphera recta per gradus et minuta: ac per horas et minuta equinoctialis."

55 (Sacrobosco and Fine 1516, sig. d1r): "Elevationes poli and Quantitates maximarum dierum."

56 On the mostly practical nature of the material added to the text of Sacrobosco in the sixteenth century, see (Crowther et al. 2015; Oosterhoff 2015; Valleriani 2017).

57 These are divided in *ratio*, *objectio*, *solutio*, *confirmatio*, *probatio*, *conclusio* and occasionally numbered (*prima ratio; secunda ratio*…).

58 The use of such *marginalia* does not appear to have been very widespread among the various editions of Sacrobosco published in the first decades of the sixteenth century. Among those which I have consulted, those which featured comparable marginal indications were the 1478 edition printed in Venice by Adam de Rottweil (Sacrobosco 2003 [1478]) and the commentary by Pedro Sanchez Ciruelo based on Pierre d'Ailly's *Quaestiones* on the *Sphaera*, first printed in 1498 in Paris (Sacrobosco et al. 1498)—the earliest edition which I was able to consult was, however, that of 1508 (Sacrobosco et al. 1508b).

59 At least one surviving copy of Fine's edition of Sacrobosco's *Sphaera* displays the use made of it by its early modern readers, as it contains hand-written marginal notes that offer complementary information and precisions, notably definitions of specific terms. This is the copy of the 1519 edition (Sacrobosco and Fine 1519) held at the Universitäts- und Landesbibliothek Sachsen-Anhalt and made accessible via http://digital.bibliothek.uni-halle.de/hd/urn/urn:nbn:de:gbv:3:3-41345 (Accessed June 2019). Although there is no information concerning the owner and consequently

Fine's contribution to the 1521 edition of Lefèvre d'Étaples's commentary on Sacrobosco's *Sphaera* (Sacrobosco et al. 1521) is mainly indicated by the inclusion of the frontispiece he had drawn for his edition of Peurbach's *Theorica planetarum* published in 1515 (Pantin 1993; Conley 1996, 98–105) and, starting with the 1527 edition (Sacrobosco et al. 1527), through the introduction of a new frontispiece in which he represented himself resting on the ground while contemplating a bi-dimensional worldly sphere situated above him (Pantin 2012). He probably also added the marginal annotations, re-engraved some of the woodblocks, and changed the design of the tables and layout of the text (Pantin 2009b, 2010, 2012; Oosterhoff 2015, 2016) (Chap. 2). However, the content of the text, of the tables, and most of the illustrations are drawn from the earlier editions of Lefèvre's commentary on Sacrobosco.

Although these editorial interventions in Sacrobosco's *Sphaera* may be regarded as minor, notably as they are not related to the content of the text, they would nevertheless have a certain impact on the reading and the reception of the work by its readers. As Isabelle Pantin has shown in this volume (Chap. 9), such interventions in the layout, the illustrations, and the editing of the text may be held as innovations, just as the commentary or the inclusion of new textual material. This is all the more significant in the case of authors such as Fine or Peter Apian (1495–1552), who were also involved in the technical aspects of the production of the book, either as engravers, as editors, or as printers, as they could then control the production of the works in order to suit their own agendas, in particular when they themselves taught mathematics, since they could aim to satisfy certain conditions required by their teaching practice through their editorial interventions.

The fact that Fine intended this work as a university textbook is not only suggested by the layout of the text, but also by the fact that he produced it while he was a professor of the Arts Faculty, which he made explicit in the title of his address to the reader (*Artium liberalium professor*) and, more generally, by the established place of Sacrobosco's *Sphaera* among the works studied in the mathematical curriculum of the Parisian University.

At that point in Fine's career, especially after the work he had done on Peurbach's *Theorica planetarum* published a year before, this edition of Sacrobosco's *Sphaera* represented a meaningful move to confirm his competence as an editor of scientific books, since he then likely intended to maintain this activity as an auxiliary source of income while teaching mathematics at the Collège de Navarre. It would certainly enable him to gain visibility in this function,[60] as Sacrobosco's *Sphaera* was a highly demanded work and therefore an easily marketable product, especially as it was part of the standard mathematical curriculum of the university (Crowther et al. 2015;

on the context in which he could have added these annotations, it is possible that such notes were written down in the context of a classroom. On this type of layout and on the practice of note-taking on printed textbooks in Parisian university classrooms at the beginning of the sixteenth century, see (Oosterhoff 2015, 2018, 74–75) (Chap. 9).

[60] As suggested by the paper of Isabelle Pantin in this volume (Chap. 9), the fact that an editor indicated his interventions, even only in the colophon, was significant.

Oosterhoff 2015; Valleriani 2017). The teaching of Sacrobosco's theory of the sphere actually represented one of the most important parts of the mathematical program of university faculties of arts since the Late Middle Ages,[61] given that it was used to introduce students to astronomy, as well as to the reading of the *De caelo* of Aristotle (384–322 BCE) (Valleriani 2017), offering them a general description of the structure of the cosmos and of the motions of the stars, as well as the geometrical tools required to apprehend them (Pantin 1995, 31–36; Oosterhoff 2015) (Chap. 2). The teaching of Ptolemy's *Almagest*, as well as the more in-depth study of planetary motions provided by the medieval *Theorica* and later by the new *Theorica* provided by Peurbach, were considered too advanced for beginners and were therefore taught at a later stage of the mathematical curriculum (Pantin 1995, 29–31; Barker 2011; Crowther et al. 2015; Oosterhoff 2015; Valleriani 2017) (Chap. 6).

For that matter, Fine's edition offered students a stand-alone version of Sacrobosco's text, devoid of any commentary, printed in an easily transportable format (*in-quarto*), and not bound to other astronomical treatises within large compendia, as was the case for many editions of Sacrobosco published at the end of the fifteenth century (Oosterhoff 2015).[62] It would therefore have been more affordable for university students and easier to bring to class.

Hence, through this edition and the other works he edited during this period, Fine contributed to the stylistic reform of scientific and pedagogical texts instigated by Lefèvre d'Étaples and his disciples at the end of the fifteenth century and which enabled Paris to have a central role in the production of printed textbooks and scientific works (Pantin 2009a, 2013a; Oosterhoff 2015, 2016, 2018, ch. 4; Valleriani 2017). As shown by Isabelle Pantin, the explicit manner in which he indicated early on his role in the various editions he worked on (including in his edition of Sacrobosco's *Sphaera*), and the evolution of this practice of identification (Conley 1996; Pantin 2009b), reveals his pride and desire to assert himself as an active promoter of the mathematical culture of his time (Pantin 2010, 2013a).[63]

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[61] On Sacrobosco's *Sphaera* and on its place in the medieval and Renaissance university curriculum, see (Thorndike 1949, 42–43; Oosterhoff 2015).

[62] See (Chap. 9) for this factor as a motivation for the development of the in-octavo tradition.

[63] It is interesting to note that, in this respect, Fine published this French paraphrase of Peurbach anonymously. His authorship of this work may be attested by the appearance of the motto "virescit vulnere virtus," which he used on all his works from the publication of his edition of the *Ars arithmetica* of Juan Martínez Silíceo in 1519 (Martínez Silíceo and Fine 1519), and also by the fact that this work was published again under his name postumously on several occasions. Although the motivations for the anonymous publication of this work remains an open question, one could conjecture that the reason why he published this work anonymously may be related to the fact that he wrote this paraphrase in French, which was a less conventional practice for works traditionally used for academic teaching. His attitude to this question may have changed in the later period, when he wrote and published (or intended to publish) under his name certain treatises in French (Fine 1543a, Fine 1551b, Fine 1556b), though this may be qualified by the fact that some treatises which were first written in French but left at the state of manuscript (perhaps intended to be read by the King or members of his entourage) were later published in Latin (such as Fine 1543b later published in Latin in Fine 1544b). Notwithstanding, the fact that he published a French version of

In this regard, the fact of providing a new edition of Sacrobosco, especially one that was more accessible to college students, would have been, for Fine, a means to demonstrate his commitment to the pedagogical model of the university, though he later went on to criticize the pedagogical methods used in the Faculty of the Arts for the teaching of mathematics (Axworthy 2016, 30–33). For that matter, despite Fine's later project to renew the mathematical teaching provided within the Parisian academic sphere, he did remain faithful, at least in the first years of his career as a royal lecturer, to the curricular model of the university, asserting, in the preface of the *Protomathesis*, the importance and propaedeutic value of mathematics for the three superior faculties of the university: medicine, law, and theology (Axworthy 2016, 186–87).[64] He also stated in the preface of the first edition of the *Cosmographia*[65] the necessity of astronomy for the students of medicine and theology, given its importance for the computation of calendars and for the determination of the dates of Easter and other mobile religious celebrations (Axworthy 2016, 172–74)[66] and given the role of judicial astrology (which represented the practical part of the science of stars, according to Fine)[67] in the determination of the favorable days for

Peurbach's treatise on planetary theory, even anonymously in 1528, could be a sign of his will to change the audience of traditional astronomy, though not necessarily to reach out to a less educated and socially lower class of people, but to a different class of privileged readers such as members of the French court.

[64] (Fine 1532, sig. AA3r): "Quod si Deus ipse, ad optatum finem dignetur aliquando perducere: videbis universam Galliam, jam fideliores amplectentem literas, caeteras nationes, non secus ac Lilium spinas, brevi tempore superare. Theologos in primis nativam sacrae scripturae consequi puritatem, tandemque fieri meliores: Philosophos sophistis succedere, et justo deinceps titulo philosophicae dignitatis laurea donari: Medicos humanis passionibus foelicius consulere, nec amplius cum tanto mortalium periculo suas venditare conjecturas: Rerum tandem humanarum judices aequiores, mitioresque succedere (quos omnium artium expedit habere cognitionem) et publicam utilitatem, potius, quàm privatam (ut tenentur) aliquando procurare: et in summa, omnes ad saniora tendere, et Christianam tandem induere pietatem." On Fine's commitment to the teaching of the masters of the University of Paris in his early years, see also (Dupèbe 1999, II, 525–26, 543).

[65] (Fine 1532 (*Cosmographia*, I.1), 102r): "Quam necessaria postmodum Apolineae sit arti, is judicare poterit, quem praesagia Hipocratis legere non pigebit: in quibus coeleste quoddam asserit esse, in quo et ipsum medicum praevidere oportet. Quod Galenus ille medicae artis restaurator in testimonium adducens, omnem substantiam corpoream animatam coelestibus signis et planetis alligari demonstrat. Adde quod viris ecclesiasticis non modo perutilis, verumetiam necessaria videtur Astronomia, idque tanto magis, quanto graviori dignitate fruuntur: ad mobilia festa, caeteraque decus et statum ecclesiae respicientia pensiculatius discutienda. Ob cuius Astronomiae neglectum, ne dicam praelatorum incuriam, a vera sacri Paschatis observatione, et evangelico ritu (horresco referens) tantum plaerunque distamus: ut pudeat hoc commune Christianorum scandalum ulterius aperire."

[66] On the uses of Sacrobosco's *Sphaera* for the domains of medicine and calendar computation, see (Cosgrove 2007; Crowther et al. 2015; Valleriani 2017) (Chap. 5); and on the tradition of computus from the early Middle Ages, see the introduction of Faith Wallis to (Bede 2004, xxxiv–lxiii; Declercq 2000, 49–95). On Sacrobosco's computus (*De anni ratione*) in particular, see (Moreton 1994).

[67] (Fine 1532 (*Cosmographia*), I.1, 102v): "…universam Astronomiam, veluti quamlibet aliam disciplinam, bifariam discindi, apud omnes, etiam vulgariter eruditos, in confesso est. Aut enim ipsum scire, magisque necessaria consyderat Astronomia, utpote, coelestes globos, sydera, eorum

bloodletting and for the administration of remedies,[68] to which should be added the production of medical almanacs (Chap. 5).[69]

It is important to note here that, for many students, astrology (both judicial and natural[70])—because of its uses in medicine, and also because of its place in Renaissance society and courtly life, as it was held (at least in principle) to guide decisions in all aspects of individual and communal human life (Azzolini 2005; Carey 2010; Eamon 2014)[71]—was often an incentive to study astronomy, and in particular Sacrobosco's *Sphaera*, which taught how to determine the positions of the zodiacal signs from different latitudes.[72] Because of its relationship to medicine, astrology actually held a privileged place among the mathematical arts in the university curriculum since its foundation.[73] The fact that Fine had been trained in medicine, although he does not appear to have practiced as a physician after

motus, et passiones, ac ejuscemodi: et theorica, vereque mathematica dicitur. Vel circa contingentia versatur, qualia sunt accidentia activorum et passivorum sphaerae, ex eorundem coelestium corporum latione provenientia: et tunc practica, et a necessarioribus remotior, sive conjecturalis appellatur." As indicated here, this distinction is drawn from Ptolemy's *Liber quadripartitum* (*Tetrabiblos*). See also (Ptolemy 1533, sig. A1r): "Rerum…in quibus est pronosticabilis scientiae, stellarum perfectio, magnas et praecipuas duas esse deprehendimus. Quarum altera quae praecedit, et est fortior, est scientia solis et lunae, nec non quinque stellarum erraticarum figuras demonstrans, quas suorum motuum causa, et unius ad aliam, eorumque ad terram collatione contingere manifestum est. Altera vero, est scientia qua explanantur et mutationes et opera quae accidunt et complentur propter figuras circuitus earum naturales eis in rebus quas circundant." On Fine's division of astronomy, see (Axworthy 2016, 201–4) and on the division and hierarchization of the parts of astronomy in the Renaissance Sacrobosco tradition prior and contemporary to Fine, see (Chaps. 4 and 5).

68 On the Galenic theory of critical days and its reception in the Middle Ages and in the Renaissance, see (Azzolini 2005; Pennuto 2008; Cooper 2013).

69 On the production of almanacs, see (Carey 2003, 2004; Eamon 2014; Kremer 2017).

70 On the difference between judicial and natural astrology, see (Vanden Broecke 2003, 18–19).

71 Yet, reservations were expressed since the Late Middle Ages as to whether occult influences should be admitted in addition to the light, heat, and motion of the planets (Vermij 2016), and as to the extent to which the stars influenced the events taking place in the lives of individuals (Vanden Broecke 2016) or as to its potential association with superstition (Vanden Broecke 2003, 9–12). J. Dupèbe (Dupèbe 1999, II, 530–33) mentions in this regard the critical discourse on occult influences held by Gregor Reisch, in his *Margarita philosophica* (which Fine edited).

72 On astrology as a motivation for the study of astronomy, and of Sacrobosco's *Sphaera* in particular, in the sixteenth century, see (Pedersen 1978; Eamon 2014; Hübner 2014) (Chaps. 2, 3, 5, 7 and 10), but also (Chap. 9), concerning the inclusion of elements on the practice of domification in the Venetian editions of Sacrobosco.

73 For this reason, astronomy and astrology were often taught in medieval universities, such as in Padua and Bologna, by professors of medicine before the creation of a distinct chairs of mathematics, which were initially designated as lectureships in astrology and/or astronomy before being related to mathematics in general (Grendler 2002, 408, 415–26). See also, on the relation between astronomy and medicine in the medieval university curriculum, (Siraisi 1981, 139–45; Siraisi 1990, 68–69, 128–29, 134–36; Vanden Broecke 2003, 12–16).

his studies,[74] would have made him clearly aware of the importance of astrology for the medical art, as would his long-lasting friendship with Antoine Mizauld (1510–1578).[75] Mizauld was a physician and a professor of medicine in Paris as well as an astrologer, and published several works on iatro-mathematics (Mizauld 1550, 1551, 1555),[76] some of which Fine contributed to (at least as the author of some of the liminary texts).

It would therefore be reasonable to think that Fine also viewed his editorial work on Sacrobosco's *Sphaera* as a contribution to the training of astrologers, to help them learn how to calculate the positions of planets in relation to the zodiacal signs and the celestial houses (Valleriani 2017), an activity in which he himself engaged as a court astrologer and which he later promoted through the publication of the *Canons des ephemerides* (Fine 1543a) and the *De duodecim caeli domiciliis* (Fine 1553a).[77] As we will see, the importance of judicial astrology as a motivation to study astronomy was also set forth in the *Cosmographia*, when Fine discussed the general structure of the cosmos and the number of celestial spheres, claiming the necessity to reject certain cosmological models in order to safeguard the validity of judicial astrology.

4 From the *Sphaera* of Sacrobosco to the *Cosmographia, sive Sphaera mundi*

While in the 1516 edition of Sacrobosco's *Sphaera*, Fine most likely intended to address a public of students, in the *Cosmographia*, he addressed a slightly different readership—namely, the audience of the royal lecturers. This new public still

74 As noted by Jean Dupèbe (Dupèbe 1999, II, 526–27), Jean Fossier designated Fine as such in the latter's edition of Johannes de Bassolis's commentary on the *Sentences* of Pierre Lombard (Bassolis 1517a, sig. ijv): "Ioannis Fosserij Matiscensis Domino Magistro Orontio Fine Delphinati, Mathematices ac Medicinae professori solertissimo" and in the fourth book (Bassolis 1517b, 3r), "Ioannis Fosserij Matiscensis in Magistrum Orontium Fine Delphinatem Astronomiae ac Medicinae professorem clarissimum."

75 Fine and Mizauld's friendship is notably manifested in the poem Mizauld wrote in Fine's honor after the latter's death in the posthumous edition of his *De rebus mathematicis hactenus desideratis libri IIII* (*Vita et tumulus Orontij*, in Fine 1556a, 5r–6r). On Fine's friendship with Mizauld, see (Dupèbe 1999, II, 528–29).

76 On Antoine Mizauld, his work on iatro-mathematics and the Parisian scene of medical astrology, see (Dupèbe 1999).

77 These works respectively deal with the art of producing almanacs (including their astrological features) and with the division of the celestial houses and of the planetary hours necessary to the casting of horoscopes. Fine also published in 1529 an *Almanach novum* aimed (as indicated by the title) to help produce elections in the context of medicine, church duties, banking, and many other important functions (*Almanach novum insigniora computi et kalendarii succincte complectens ad longos annos duraturum, viris ecclesiasticis, medicis, chirurgicis, trapezitis, quibusvis tandem hominum conditionibus necessarium*). On the context of its publication, see (Dupèbe 1999, II, 540–41).

included university students, but was also composed of humanists, curious notables, and members of the court, and was in principle open to anyone, especially as the teaching of the royal lecturers did not lead to any degree (Pantin 2006). This gave Fine and the other royal lecturers the flexibility to propose a teaching program that was relatively different from that which was provided at the Faculty of the Arts (when it was provided at all). In Fine's case, this reformed mathematical teaching program was communicated, as noted above, through the publication of the *Protomathesis* in 1532.[78] It is within this work that appeared the first edition of the *Cosmographia*, which refers for a considerable part of its content and structure to the textual paradigm of the *Tractatus de sphaera.*[79]

The fact that Fine's *Cosmographia* relates to Sacrobosco's *Sphaera* in terms of its content, composition, and finality is suggested by its title: *Cosmographia, sive sphaera mundi*, a title which evolved from 1542 into *Sphaera mundi, sive cosmographia* (Fine 1542a, b, 1551a, b, 1555), making its focus on the theory of the sphere more obvious (Mosley 2009).[80] What this title also indicates is that this teaching pertained to cosmography,[81] which was, in the sixteenth century, properly developed into a

[78] The pedagogical aim of the *Protomathesis* is first suggested by the context of its publication, which coincides with the beginning of Fine's career as royal lecturer. His new function as royal lecturer is indicated in the title of the work (*Orontij Finei Delphinatis, liberalium disciplinarum professoris Regii, Protomathesis*). In the preface of *L'Esphere du monde*, which corresponds to the French translation of the *Cosmographia* published in 1551, Fine clearly described the pedagogical mission the King François I had assigned to him as a royal lecturer, which he fulfilled, as he writes then, through ordinary lectures and through the publication of written works. (Fine 1551b, sig. A3r): "Et fuz d'autant plus incliné audit estude, que je cogneu le feu Roy vostre pere (auquel Dieu doint repos eternel) outre le bon jugement qu'il avoit de toute chose, comme prince bien né, porter singuliere affection ausdittes mathematiques: desquelles il me ordonna finablement publique interpreteur en l'Université de Paris, ou j'ay fait mon devoir, tant par leçons ordinaires, que par oeuvres escrittes, les remettre sus, & icelles demonstrer l'espace de trent'ans & plus." As seen above, Fine also reiterated the propaedeutic role of mathematics for the higher university faculties in the preface of the *Protomathesis*, manifesting his will to offer a complete mathematical course for the students and masters of the Faculty of Arts, in addition to the new public to which his teaching was open.

[79] See also, for comparison, the place given to the teaching of the sphere in the pedagogical programs of Jacques Lefèvre d'Étaples (Chap. 2), Conrad Tockler (Chap. 5), Pedro Sanchez Ciruelo (Chap. 3), Franco Burgersdijk (Chap. 11), as well as in those of Portuguese and Spanish mathematics professors more generally (Chaps. 7 and 10).

[80] The association between the theory of the sphere and cosmography is also indicated by the title of the treatise of Antoine Mizauld, *De mundi sphaera, seu cosmographia, libri tres*, which was published in 1552 and which Fine contributed to editing. On other works that indicate in their title the connection between cosmography and the theory of the sphere, see (Oosterhoff 2015; Valleriani 2017) (Chap. 7).

[81] It may be noted that the *Theorique des cielz*, which was published four years before the *Cosmographia* and in which Fine gives the main elements of the general description of the universe (serving him also for the corresponding part of the *Cosmographia*), he explicitly identified cosmography with the theory of the sphere; (Fine 1528, 3r): "[le mouvement qui est appelle diurnel] appartient traicter en la Cosmographie, ou traicte de l'esphere mondaine: come nous avons faict, et doibt estre presuppose devant ce livre cy." See also (Fine 1528, 33v): "comme nous avons amplement declaré au traicté de la Cosmographie, ou de la Sphere du monde." Here Fine refers to

discipline in its own right, bringing together metrical geography and the theory of the sphere.[82] It was thus not only conceived as a practice relating to the production of the *mappa mundi*, or to the cartographical description of the contours of the terrestrial world (for which reason the title of cosmographer, in the Iberian peninsula, was attributed to those in charge of casting navigational charts and of constructing mathematical instruments)[83] or as a synonym of geography, following the designation of Ptolemy's *Geographia* as *Cosmographia* by its fifteenth-century translator, Jacopo d'Angelo (1360–1410) (Broc 1980; Milanesi 1994; Cosgrove 2007; Besse 2009; Mosley 2009; Tessicini 2011),[84] but also as relating to spherical astronomy. The shifts in meaning of the term cosmography (from maps to treatises, from applied practical knowledge to academic teaching, or from the consideration of the terrestrial globe to that of the universe in its totality) display the various orientations and also the tensions inherent to cosmographical knowledge in the sixteenth century (Cosgrove 2007).[85] These show also that cosmography, as well as geography, was a knowledge in transformation, not only with regard to its content (by integrating the new geographical discoveries), but also with regards to its status, since neither geography nor cosmography was acknowledged as a proper discipline or object of teaching (distinct from natural philosophy, astronomy, or natural history) before the Renaissance (Besse 2003, 10).[86] It remains that, within the sixteenth-century treatises on cosmography, the different definitions of cosmography remained connected, since, as shown by Fine's *Cosmographia* in particular, it was also defined as the means to describe the universe in its entirety and in its various parts, though what cosmographical treatises offered was less a visual description of the world and of its two main regions than a method or set of principles necessary to produce such a description (Besse 2009; Mosley 2009).

In this framework, the mapping of the universe in its two main parts, celestial and terrestrial, required the projection of the circles which divide the celestial sphere in

a prior teaching of cosmography or the theory of the sphere on which he would have previously worked. It is not clear to which treatise he is referring. Perhaps he had already written his *Cosmographia* in 1528. Indeed, as it was already printed two years before the actual publication of the *Protomathesis* from the date of the frontispiece of its cosmographical part (Fine 1532, 101r), it is not impossible that he had written it before 1528. But he could also be referring to his edition of Sacrobosco's *Sphaera*, or less likely to the discourse he has presented in the first pages of the *Theorique des cielz*, though this may hardly be called a treatise. I would like to thank Isabelle Pantin for her help in verifying the presence of the relevant passages in the 1528 version, which included a visit on her part to the Bibliothèque Nationale de France.

[82] On the development of sixteenth-century cosmography and cosmographical culture, see (Mosley 2009; Gaida 2016), as well as (Chap. 2).

[83] On this topic, see (Navarro Brotóns 2004; Portuondo 2009; Mosley 2009; Cattaneo 2016; Almeida 2017) (Chaps. 7 and 10).

[84] The earlier meanings of the term *cosmographia*, for instance in the works of Cassiodorus and Bernard Silvestris, are also described in (Cosgrove 2007; Mosley 2009).

[85] On the various audiences and applications of the teaching of cosmography in the Iberian peninsula, see (Chap. 7).

[86] On the entry of cosmography into the university mathematical curriculum in sixteenth-century Spain, see (Chap. 7).

spherical astronomy onto the terrestrial globe, establishing a correspondence between the systems of longitudinal and latitudinal positioning of celestial objects and terrestrial places (Broc 1980, 66–68; Milanesi 1994; Besse 2003, 36–37, 46–48; Besse 2009; Mosley 2009). Through the mathematical correspondence this establishes between the celestial sphere and the terrestrial globe, cosmography is presented as an essentially dual teaching.[87] Geography is indeed assigned a comparable epistemological status to astronomy,[88] leaving aside the more qualitative approach of Strabo (ca. 63 BCE–ca. 24) and Pomponius Mela (died ca. 45) in favor of the mathematical mode of description of the earthly contours followed by Ptolemy in the *Geography*.[89] In Fine's prefaces to the 1551 edition of the *Cosmographia*, this double orientation of cosmography is justified by the double function of man—on one hand, called on to inhabit the earth; on the other, invited to contemplate the heavens (Besse 2009; Mosley 2009; Axworthy 2016, 154–59).[90]

Through the development of cosmography as a discipline, the teaching of Sacrobosco's theory of the sphere was absorbed into a larger framework. The *Tractatus de sphaera* provided in this regard one of the most adequate teachings of

[87] The two orientations of cosmography, and their correspondence with the two main parts of the cosmos, are clearly expressed by Fine in the 1542 edition of the *Cosmographia*; (Fine 1542b, 5r–v): "Unde *κόσμος* a Graecis dicitur: et quae de Mundo traditur disciplina, *κοσμογραφία* (de qua praesentis tractare est instituti) respondenter vocitatur. Est enim Cosmographia, Mundanae structurae generalis ac non injucunda descriptio: prima Astronomiae partem, atque Geographiam, hoc est, caeli terraeque rationem comprehendens."

[88] On the epistemological status of geography in Fine's mathematical thought, see (Besse 2009; Axworthy 2016, 329–49).

[89] For an overview of Ptolemy's approach to geography, see the introduction of J. Lennart Berggren and Alexander Jones to their annotated translation of the *Geography* (Ptolemy 2000, 3–54). On the content and the influence of Ptolemy's *Geography* in the Renaissance, especially on sixteenth-century treatises on the sphere, see (Besse 2003, 29–30, 111–48; Oosterhoff 2015); in relation to Fine's cartographical work specifically, (Brioist 2009b) and, in a more general perspective, (Šālew and Burnett 2011).

[90] (Fine 1551a, sig. aa2r–v): "Inter admiranda naturae sive Dei miracula, duo sunt quae omnium miraculorum superare videntur admirationem: Mundus scilicet, et homo. Quorum partes insigniores sunt rursum duae: utpote, immortalis vel aeterna, et ea quae corruptioni, atque mutationi semper obnoxia est. Mundi nanque pars aeterna, est ipsum caelum, divino lumine Solis illustratum, et suis in primis ornatum corporibus, regulari et indefessa latione circunductis: quae unum atque eundem ordinem perpetuo videntur observare, utpote, quem ex Deo ab ipsa Mundi creatione sunt adepta. Pars vero corruptibilis ipsius Mundi, et quae nunquam in eodem statu permanet, est ipsa elementorum moles, intra caeli cavaturam conglobata: assidua quidem agitatione pertubata, atque alterata, omnium generatorum materia, et alimentum. Haud dissimiliter, homo ex duplici natura compositus esse videtur: aeterna videlicet, hoc est, ipsa anima Deo simili, quam nonnulli substantialem vocant homine: et mortali, utpote corporea, quae ut ex ipsis constare perhibetur elementis, sic et in eadem elementa tandem resolvitur. Homo itaque sic efformatus est, ut utranque suam originem aeternam videlicet, et corruptibilem recognoscere possit et debeat: hoc est, incolere atque gubernare terrena, et simul intelligare et admirari quae coelestia sunt. Nempe cui soli inter animantia, portio mentis ab ipso Deo, caeli et animae, ac omnium eorum quae Mundus comprehendit opifice atque rectore, concessa est." Jean-Marc Besse (Besse 2009) also shows that the duality was interpreted as a double view-point of the mathematician on the cosmos, which cosmography both connects and encompasses.

the astronomical circles that divide the celestial sphere and which the cosmographer is required to project onto the terrestrial globe (Cosgrove 2007).[91] Sacrobosco's *Sphaera* thus became the natural starting point for the mathematical analysis and treatment of the terrestrial space[92] at a global and local level (Besse 2009; Brioist 2009b).[93] This relation between the theory of the sphere and geography is clearly expressed by the content and division of Fine's *Cosmographia*, in which the first four books are dedicated to the description of the celestial region of the cosmos (leaving aside, however, the trajectories of the moon and the five planets) and the fifth book to the description of the earth.[94]

The topics tackled in the *Cosmographia* which properly deal with spherical astronomy are in large part the same as those in Sacrobosco's *Sphaera*, although Fine does not explicitly acknowledge this inheritance, which reveals the traditional and omnipresent character of this textual model in sixteenth-century treatises on the sphere (Mosley 2009; Oosterhoff 2015; Valleriani 2017). Sacrobosco's name is indeed never mentioned, as Fine rather refers in general terms to previous authors, thereby acknowledging the existence of an established tradition. He does not either tacitly take up any parts of Sacrobosco's text, as was sometimes done in early modern books pertaining to the theory of the sphere (Valleriani 2017, 428). In most pre- and early-modern treatises on spherical astronomy and on cosmography, the imprint of the canonic model of Sacrobosco's *Sphaera* remains underlyingly present, as shown also by other cosmographies written and published before Fine's *Cosmographia*, such as the *Cosmographiae introductio* of Martin Waldseemüller (1470–1520) and Matthias Ringmann (1482–1511) (Waldseemüller and Ringmann

[91] As shown by (Chap. 2) through the exemplary case of Lefèvre d'Étaples's 1494 commentary on Sacrobosco, this relation also took place in a reversed order, with the integration of cosmography within the framework of the *Sphaera*, the addition of many elements from Ptolemy's *Geographia*, as well as of various tables and computation methods necessary to the cosmographical practice. On the relation between Sacrobosco's *Sphaera* and cosmography in the sixteenth century, see also (Oosterhoff 2015; Valleriani 2017) (Chaps. 7 and 9).

[92] As indicated by Pantin in this volume (Chap. 9), Peter Apian wrote in the address to the reader of his first edition of Sacrobosco's *Sphaera* (Sacrobosco and Apian 1526, A1v) that this edition was to be regarded as a preamble to his introduction to Ptolemy's *Geographia*: "…visum est mihi haud inutile fore, si ingenuis adolescentibus primum omnium Astronomiae rudimenta praelegerem, Sphaeram JANI de Sacrobusto accuratissime interpretarer. Futurum tandem existimans ut ex sphaerae circulorumque ejus attenta cognitione, spaciorum terrae coelique absoluta notitia proveniret."

[93] As was shown by Besse (Besse 2009), in Fine's *Cosmographia*, geography (mapping of the earth), chorography (regional mapping), and hydrography (marine cartography) are not distinguished from an epistemological point of view, as they are in the classifications found in contemporary cosmographical and geographical treatises.

[94] (Fine 1532, 101r): "Liber primus, de universa Mundi compagni, sive structura; Liber secundus, de principalioribus circulis in Mundana sphaera prudenter imaginatis; Liber tertius, de signorum et arcuum ascensionibus et descensionibus: atque de syderum ortu et eorundem occasu; Liber Quartus, de dierum et horarum tam aequalium, quàm inaequalium, et umbrarum rationibus: deque singulorum accidentibus, juxta varium sphaera situm observatis; Liber quintus, de geographicis, Chorographicis, et hydrographycis institutis."

1907), the *Liber cosmographicus* of Peter Apian (Apian 1524),[95] or the *Rudimentorum cosmographiae* of Johannes Honterus (1498–1549) (Honterus 1535, 1440–63).

The fact that Fine never mentions Sacrobosco's name in this context, even as an authority among others, may seem paradoxical given the importance of the *Tractatus de sphaera* in Fine's early career as a master of the Faculty of the Arts and as an editor of scientific books, but also given the clearly identifiable imprint of Sacrobosco's treatise on the structure of the *Cosmographia*, to which could be added its significance for the development of early modern cosmography more generally. The absence of any explicit mention of Sacrobosco in the *Cosmographia*, along with the fact that he does not (even tacitly) quote Sacrobosco's text, may be due to Fine's will to detach himself in name and in principle from what could by then be considered as "the old sphere" in order to promote his own version of "the new sphere"—to take up the distinction between the *theorica vetus* and the *theorica nova*—[96] while surreptitiously basing the latter on the former. The will to revise the doctrine of the sphere devised by Sacrobosco's *Sphaera* transpires in particular through Fine's criticisms of the literary parts of the traditional teaching on the sphere, which is one of the distinctive marks of Sacrobosco's treatise, as will be shown later.

The fact of following the textual content and design of the *Sphaera* without mentioning the name of Sacrobosco is not unheard of over its period of diffusion in print. Matteo Valleriani (Valleriani 2017, 427–28) established that, among the nearly 400 different printed treatises that may be counted as belonging to the tradition of the *Tractatus de sphaera* between 1472 and 1697, a certain number of works relate to Sacrobosco's treatise by their structure and by their visual material without mentioning Sacrobosco's name (Chap. 1).[97] Even among the works that quote Sacrobosco's text (entirely or partially), such as the *Elementa sphaerae mundi sive cosmographiae in usum Scholae Mathematicae Basilensiis* of Peter Ryff (1552–1629) (Ryff 1598) analyzed by Matteo Valleriani (Valleriani 2017) or the treatise on the sphere of André do Avelar (Avelar 1593), considered in this volume by Roberto de Andrade Martins (Chap. 10), there are cases of treatises that do not feature his name. Moreover, sixteenth-century cosmographies, and in particular

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[95] On Apian's contribution to sixteenth-century cosmography, see (Gaida 2016).

[96] When Georg Peurbach proposed his own version of the geometrical system intended to model the motions of the planets (*theorica planetarum*) in the fifteenth century, in order to replace the system previously taught in the universities, he presented it explicitly as a new model (*Novae theoricae planetarum*) aimed at replacing this old system (*Theorica planetarum antiqua*). In spite of the popularity of Peurbach's new version, the old *theorica* continued to be printed, sometimes with the new *theorica*, up to the sixteenth century. On the history of the *Theorica planetarum*, see (Pedersen 1981). A parallel may therefore be made between this development and the fact that Sacrobosco's *Sphaera* continued to be printed up to the seventeenth century, alongside more modern treatises on the theory of the sphere.

[97] For a list of the various printed editions of Sacrobosco's *Sphere*, see the online database coordinated by Matteo Valleriani: https://sphaera.mpiwg-berlin.mpg.de, as well as that of Roberto de Andrade Martins: http://www.ghtc.usp.br/server/Sacrobosco/Sacrobosco-ed.htm (Accessed June 2019) and the bibliographical inventory in (Hamel 2004, 2014). Complementary information may be found in (Thorndike 1949; Gingerich 1988; Pedersen 1995; Valleriani 2017).

those mentioned above, do not mention Sacrobosco's name as the main source of their doctrine of spherical astronomy either, in spite of their reappropriation of parts of the *Sphaera*'s content, design and images.

Although Fine's *Cosmographia* does not explicitly relate to Sacrobosco's *Sphaera* and does therefore not feature any parts of Sacrobosco's text, but rather aims to offer a new teaching on the worldly sphere,[98] the first edition of the *Cosmographia* maintains the style of a commentary on a canonic text, as would a commentary on the *Sphaera*, each chapter starting by enunciating a general teaching on the topic at stake and offering, in a separate section, a commentary on this teaching printed in a smaller font (Fig. 8.1). In the main part, each element of teaching is indicated by a letter in superscript, which allows us to identify the commentary in the second part, marked by the corresponding letter in the margin. This commentary-type exposition disappeared in the subsequent editions and translations of the *Cosmographia*, apart from the unabridged version of 1542 (Fine 1542a), where the main text is enriched with portions of the initial commentary.[99] The fact that this textual disposition was intended as a form of commentary is confirmed by the subtitle on the main title-page of the *Cosmographia*[100] and was made explicit by Cosimo Bartoli in his Italian translation of the *Cosmographia* (Fine 1587).[101] This textual layout, which clearly confirms the pedagogical aim of this work, did not commonly appear in contemporary cosmographical treatises.

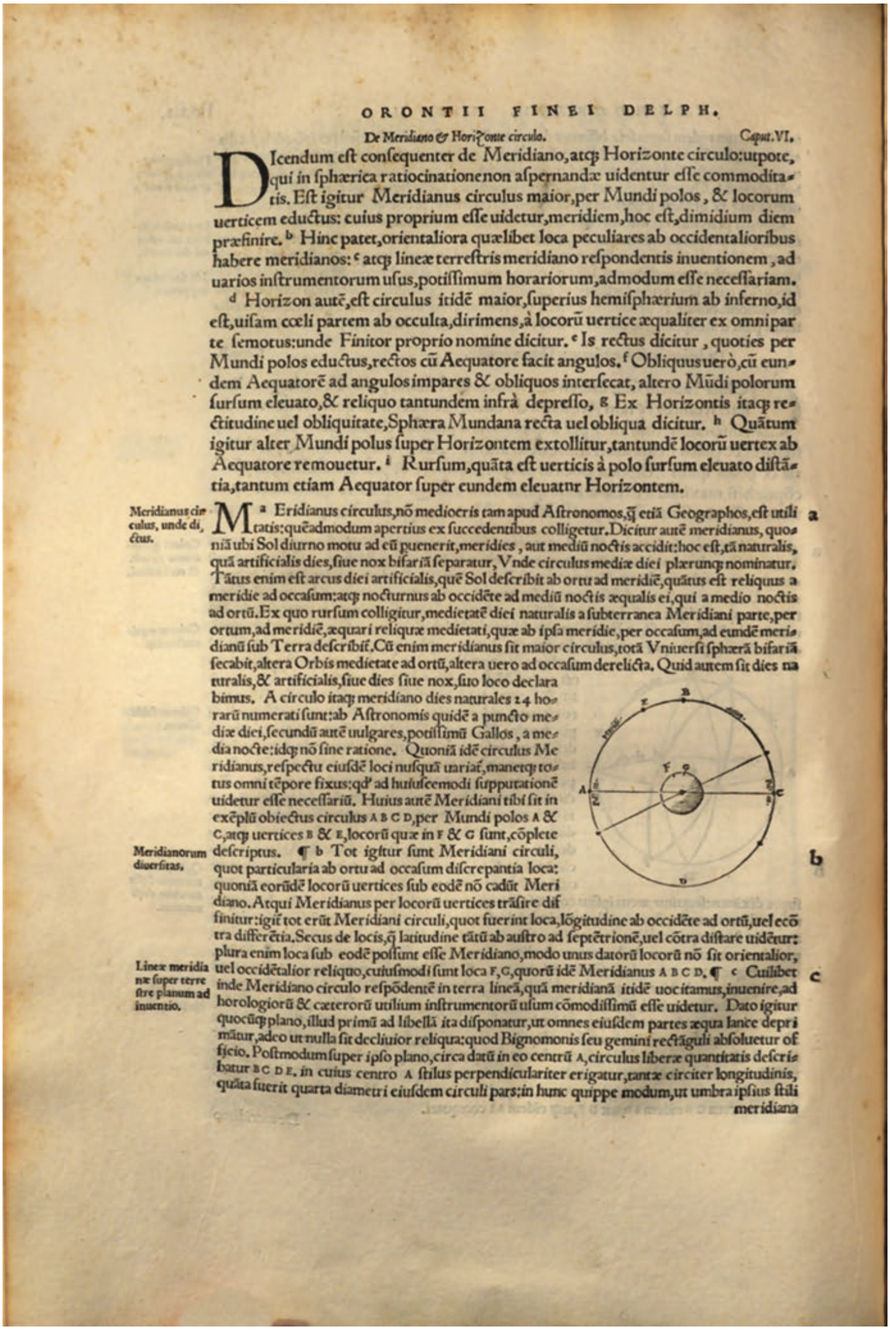
With regard to the division and ordering of its content, Fine's *Cosmographia* follows quite closely the structure and thematic division of the *Sphaera*, and this more than other early sixteenth-century cosmographical treatises, including those mentioned above, which put a greater emphasis on geography, and especially on descriptive geography and on the study of populations (Mosley 2009). Indeed, in the cosmographies of Waldseemüller/Ringmann (Waldseemüller and Ringmann 1907), Apian (Apian 1524),

[98] A good summary of the content of the *Cosmographia* is found in the preface to the 1555 edition (Fine 1555, sig. ∗3r–v): "Primò libro universa Mundi structura, hoc est, caelestis ac elementaris regionis descriptio, continetur. In secundo, de circulis ipsi mundanae sphaerae coaptatis (à quibus tota motus caelestis ratiocinatio, instrumentorum quoque Astronomicorum pendet origo) tractatur: De via insuper solari, quae Zodiacus vocitatur, illiùsque declinatione, et duodenario signorum numero. Tertius liber, totus est de stellarum, atque signorum Zodiaci revolutionibus, quas ascensiones atque descensiones appellant: déque illarum differentiis, pro dato sphaerae situ contingentibus. Quarto agitur de naturalibus, atque artificialibus diebus: De aequalibus insuper, et inaequalibus horis, et horum omnium tam in recta, quàm in obliqua sphaerae positione facta diversitate. Quintus et ultimus (è caelesti in terrestrem descendendo molem) Geographicis, Chorographicis, ac Hydrographicis deputatus est rebus, ac disciplinis: cuiusmodi sunt parallelorum et climatum rationes, locorum longitudines atque latitudines, viatoriae illorum distantiae, seu directae profectiones itinerum, planarum denique chartarum (sic enim Geographicas, vel Hydrographicas projectiones, in planum extensas appellant) tam universales, quàm particulares descriptiones, et his similia."

[99] On the successive transformations brought to the text of the *Cosmographia*, see (Pantin 2010, 2013a).

[100] (Fine 1532, 101r): "De Cosmographia, sive mundi sphaera libri V. Propriis eiusdem Orontij commentariis elucidate."

[101] Bartoli wrote in front of each main part the designation *Testo* and in front of the second part, *Commento*.



ORONTII FINEI DELPH.

De Meridiano & Horizonte circulo. Caput.VI.

Dicendum eſt conſequenter de Meridiano, atq; Horizonte circulo: utpote, qui in ſphærica ratiocinatione non aſpernandæ uidentur eſſe commoditatis. Eſt igitur Meridianus circulus maior, per Mundi polos, & locorum uerticem eductus: cuius proprium eſſe uidetur, meridiem, hoc eſt, dimidium diem præfinire. [b] Hinc patet, orientaliora quælibet loca peculiares ab occidentalioribus habere meridianos: [c] atq; lineæ terreſtris meridiano reſpondentis inuentionem, ad uarios inſtrumentorum uſus, potiſſimum horariorum, admodum eſſe neceſſariam.

[d] Horizon autē, eſt circulus itidē maior, ſuperius hemiſphærium ab inferno, id eſt, uiſam cœli partem ab occulta, dirimens, à locorū uertice æqualiter ex omni parte ſemotus: unde Finitor proprio nomine dicitur. [e] Is rectus dicitur, quoties per Mundi polos eductus, rectos cū Aequatore facit angulos. [f] Obliquus uerò, cū eundem Aequatorē ad angulos impares & obliquos interſecat, altero Mūdi polorum ſurſum eleuato, & reliquo tantundem infrà depreſſo. [g] Ex Horizontis itaq; rectitudine uel obliquitate, Sphæra Mundana recta uel obliqua dicitur. [h] Quātum igitur alter Mundi polus ſuper Horizontem extollitur, tantundē locorū uertex ab Aequatore remouetur. [i] Rurſum, quāta eſt uerticis à polo ſurſum eleuato diſtātia, tantum etiam Aequator ſuper eundem eleuatur Horizontem.

Meridianus circulus, unde dictus.

M[a] Eridianus circulus, nō mediocris tam apud Aſtronomos, q̄ etiā Geographos, eſt utilitatis: quēadmodum apertius ex ſuccedentibus colligetur. Dicitur autē meridianus, quoniā ubi Sol diurno motu ad eū puenerit, meridies, aut mediū noctis accidit: hoc eſt, tā naturalis, quā artificialis dies, ſiue nox bifariā ſeparatur, Vnde circulus mediæ diei plærunq; nominatur. Tātus enim eſt arcus diei artificialis, quē Sol deſcribit ab ortu ad meridiē, quātus eſt reliquus a meridie ad occaſum: atq; nocturnus ab occidēte ad mediū noctis æqualis ei, qui a medio noctis ad ortū. Ex quo rurſum colligitur, medietatē diei naturalis a ſubterranea Meridiani parte, per ortum, ad meridiē, æquari reliquæ medietati, quæ ab ipſa meridie, per occaſum, ad eundē meridianū ſub Terra deſcribit. Cū enim meridianus ſit maior circulus, totā Vniuerſi ſphærā bifariā ſecabit, altera Orbis medietate ad ortū, altera uero ad occaſum derelicta. Quid autem ſit dies naturalis, & artificialis, ſiue dies ſiue nox, ſuo loco declarabimus. A circulo itaq; meridiano dies naturales 24 horarū numerati ſunt: ab Aſtronomis quidē a puncto mediæ diei, ſecundū autē uulgares, potiſſimū Gallos, a media nocte: idq; nō ſine ratione. Quoniā idē circulus Meridianus, reſpectu eiuſdē loci nuſquā uariat, manetq; totus omni tēpore fixus: qđ ad huiuſcemodi ſupputationē uidetur eſſe neceſſariū. Huius autē Meridiani tibi ſit in exēplū obiectus circulus A B C D, per Mundi polos A & C, atq; uertices B & E, locorū quæ in F & G ſunt, cōplete deſcriptus.

Meridianorum diuerſitas.

¶ [b] Tot igitur ſunt Meridiani circuli, quot particularia ab ortu ad occaſum diſcrepantia loca: quoniā eorūdē locorū uertices ſub eodē nō cadūt Meridiano. Atqui Meridianus per locorū uertices trāſire diffinitur: igit̄ tot erūt Meridiani circuli, quot fuerint loca, lōgitudine ab occidēte ad ortū, uel ecōtra differētia. Secus de locis, q̄ latitudine tātū ab auſtro ad ſeptētrionē, uel cōtra diſtare uidētur: plura enim loca ſub eodē poſſunt eſſe Meridiano, modo unus datorū locorū nō ſit orientalior, uel occidētalior reliquo, cuiuſmodi ſunt loca F, G, quorū idē Meridianus A B C D.

Lineæ meridianæ ſuper terreſtre planum ad inuentio.

¶ [c] Cuilibet inde Meridiano circulo reſpōdentē in terra lineā, quā meridianā itidē uocitamus, inuenire, ad horologiorū & cæterorū utilium inſtrumentorū uſum cōmodiſſimū eſſe uidetur. Dato igitur quocūq; plano, illud primū ad libellā ita diſponatur, ut omnes eiuſdem partes æqua lance deprimātur, adeo ut nulla ſit decliuior reliqua: quod Bignomonis ſeu gemini rectāguli abſoluetur officio. Poſtmodum ſuper ipſo plano, circa datū in eo centrū A, circulus liberæ quantitatis deſcribatur B C D E, in cuius centro A ſtilus perpendiculariter erigatur, tantæ circiter longitudinis, quāta fuerit quarta diametri eiuſdem circuli pars: in hunc quippe modum, ut umbra ipſius ſtili meridiana

Fig. 8.1 The commentary-like layout of the *Cosmographia.* The main teaching is clearly separated from the commentary and referred to in its different sections by letters placed in the margins. From (Fine 1532). Augsburg, Staats- und Stadtbibliothek—2 Math 30, fol. 112v, urn:nbn:de:bvb:12-bsb11199761-8 or Honterus (Honterus 1535), the topics dealt with by Sacrobosco in the first three chapters are treated only partially and/or superficially, for instance as a preliminary introduction to its geographical part. In comparison, the topics dealt with by Sacrobosco in these first three books are extensively dealt with in Fine's *Cosmographia* and in practically the same order. Admittedly, some topics which were tackled separately by Sacrobosco, and which were marked as distinct sections in previous printed editions (also in Sacrobosco and Fine 1516), were sometimes brought together in one chapter (as were the tropics, the polar circles, and the five zones); and notions (such as natural days) which, on the contrary, were not dedicated a specific exposition in Sacrobosco's text, constitute the subject of a separate chapter in Fine's work. This denotes a will, on Fine's part, to reorganize and clarify the content of the traditional teaching on the sphere and to make it more accessible to readers less familiar with it.

The main structure of the *Cosmographia* is also slightly different from that of the *Sphaera*. Although the topics considered by Sacrobosco in the first two books (on the general structure of the world and on the circles dividing the celestial sphere) are respectively dealt with in the first two books of the *Cosmographia,*[102] the topics discussed in Sacrobosco's third book are distributed in two books (book III and IV) and extend to a part of the third book (book V), therefore occupying the last three books of Fine's treatise—that is, book III for the rising and setting of the signs,[103] book IV for the motion of the sun and its influence on the duration of light and shadows at different latitudes on Earth,[104] and book V for the theory of climates, which is then integrated into the geographical part of the *Cosmographia.*[105] Moreover, certain complementary chapters pertaining to the more modern teaching of the sphere are occasionally inserted between some of the more traditional chapters and various elements of a more practical nature are added in the last four books. Yet, in spite of these differences, Fine's *Cosmographia* stands out among the sixteenth-century cosmography treatises by its strong focus on the theory of the sphere,[106] highlighted in particular by the fact that the astronomical section of the work covers four out of

[102] (Fine 1532, 102r): "Liber primus, de generali ipsius Mundi compagine, sive structura" and (108r): "Liber secundus cosmographiae, sive mundi sphaerae, De principalioribus circulis in eadem sphaera prudenter imaginatis." An exception is the part on the dimensions of the earth, which is integrated to the fifth book of the *Cosmographia*; (Fine 1532, V.4, 149r): [*in marg.* Quantus universus terrestris ambitus per eundem Ptolemaeum.]

[103] (Fine 1532, 118v): "Liber tertius cosmographiae, sive mundi sphaerae: De signotum et arcuum ascensionibus et descensionibus: atque sydorum ortu et eorundem occasu."

[104] (Fine 1532, 130v): "Liber quartus cosmographiae, sive mundi sphaerae, De dierum et horarum tam aequalium, quàm inaequalium, et umbrarum ratione: deque singulorum accidentibus, juxta varium sphaerae situm observatis."

[105] (Fine 1532, 141v): "Liber quintus et ultimus cosmographiae, sive mundi sphaerae: De geographicis, chorographicis, et hydrographicis institutis."

[106] This may also be corroborated by the fact that, in the title of the 1542 and of the later editions of the *Cosmographia*, the teaching offered is first designated as pertaining to the theory of the sphere and is specifically assimilated to the first part of astronomy. See, for example, (Fine 1542b): *De Mundi sphaera, sive Cosmographia, primàve Astronomiae parte*.

five books,[107] and also by the fact that, within this part, the disposition and structure of Sacrobosco's *Sphaera* remains overall clearly identifiable (Mosley 2009).[108]

More precisely, the topics common to the first book of the *Sphaera* and to the first book of the *Cosmographia*[109] are the distinction between the elementary and the heavenly regions, along with their respective divisions,[110] the motions and the sphericity of the heavens,[111] the immobility, sphericity, and centrality of the earth in the middle of the universe.[112] It may be noted here that, in the *Theorique des cielz* (Fine 1528), Fine added to his exposition of Peurbach's planetary theory a preliminary exposition on the general structure of the universe, which presents the above-described content.[113]

In the second book of the *Cosmographia*, Fine followed the model of the *Sphaera* by presenting the various astronomical circles that divide the worldly sphere[114]—

[107] The four first books occupy 38 of the 53 folios of the *Cosmographia*.

[108] The commentary on the *Sphaera* of André do Avelar (Chap. 10) and the edition of Franco Burgersdijk (Chap. 11) are other examples of works which made substantial changes to the structure of Sacrobosco's text, but in which the original model stays clearly recognisable. Other examples of such works, including Fine's *Cosmographia*, are mentioned in by (Valleriani 2017) (Chap. 9).

[109] For the sake of conciseness, I will mainly compare the titles of the sections or chapters (in italics) and some of the corresponding *marginalia* (in square brackets and indicated by "*in marg.*") given in Fine's 1516 edition of Sacrobosco and in the *Cosmographia* to summarize the corresponding content.

[110] (Sacrobosco and Fine 1516, book I, sig. a2v–a3r): [*in marg.* Divisio sphaerae mundi elementaris Regio. Ordo elementorum. De coelorum substantia. De eorum numero]. See also (Fine 1532 (*Cosmographia*), I.1, 102v): "De praecipuis Mundi partibus. [*in marg*. Elementaris regio. Regio coelestis.];" (I.2, 102v–103v): "Quibus constet elementaris regio, ac de elementorum ordine. [*in marg.* Cur quatuor tantum elementa. Quatuor elementa omnium mixtorum radices. Quatuor elementa cur simplicia dicta. De elementorum ordine. De situ elementorum. Terra cur frustulatim discooperta.]" and (I.3, 103v–04v): "De coelestium orbium numero, atque positione." [*in marg.* Coelum quinta essentia nominatum. Coelum in octo principales orbes distributum.]

[111] (Sacrobosco and Fine 1516, I, sig. a2v): "Quae si forma mundi. [*in marg*. De motibus celorum]" and (sig. a3r): "De celi rotunditae." See also (Fine 1532, I.4, 104v–05v): "Quaenam coelestium orbium figura, atque motus qualitas" [*in marg*. Quod coelum sit sphaericum Prima ratio, à commoditate. Quae dicantur isoperimetrae. Secunda ratio à necessitate. Quod coelum circulariter moveatur. Motus universalis totius coeli. Motus secundus orbibus peculiaris, priori contrarius.] and (I.5, 105r–v): "De generali eorundem coelestium motuum expressione. [*in marg.* Primus motus quem diurnum appellamus, unde proveniat. De proprio singulorum orbium motu]."

[112] (Sacrobosco and Fine 1516, I, sig. a3v): "Quod terra sit rotunda;" (sig. a4r): "Quod acqua sit rotunda. Quod terra sit centrum mundi" and "De immobilitate terrae." See also (Fine 1532, I.6, 106r–07v): "De quiete, loco, et figura ipsius Terrae. [*in marg*. Quod terra non movetur circulariter. Terra non movetur motu recto, secundum totam. Quod terra est in medio totius Universi. Telluris et aquae superficies unica. Quod idem globus, à septentrione ad austrum sit rotundus. Quod globus ex Tellure et acqua resultans respectu universi, imperceptibilis sit quantitatis. Terra mundi centrum esse videtur.]"

[113] The relation between the *Theorique des cielz* and the *Cosmographia* is confirmed by the fact that these works contain the same diagrams for the spheres of the elements (Fine 1528, 2v; Fine 1532, 103r) and for the celestial spheres (Fine 1528, 3r; Fine 1532, 104r).

[114] (Sacrobosco and Fine 1516, II, sig. a4v): "Capitulum secundum de circulis ex quibus sphaerae materia componitur: et illa super coelesti quae per istam imaginatur componi intelligitur." See also (Fine 1532, II.1, 108r): "Liber secundus cosmographiae, sive Mundi Sphaerae, De principalioribus circulis in eadem Sphaera prudenter imaginatis."

namely, the equinoctial or celestial equator (along with the poles of the world),[115] the colures,[116] the meridians and the horizons,[117] the tropics, the polar circles, as well as the zodiac, the ecliptic and the various modes of division and representation of the zodiacal signs in the sphere,[118] to which adds the division of the heavens into five zones.[119] All these circles were considered again in the first chapter of the fifth book, through their projection onto the terrestrial globe.[120]

The topics dealt with by Sacrobosco in the third chapter of the *Sphaera* are those with which Fine dealt most extensively, as they cover books III and IV, and a part of book V. The third book, which deals with the risings and settings of the signs, allows

115 (Sacrobosco and Fine 1516, II, sig. a4v): [*in marg.* Quid circulus equinoctialis. De duobus polis et nominibus eorum] (Fine 1532, *Cosmographia*, II.1, 108r): "De Aequatore circulo, et Mundi polis. [*in marg.* Aequator primus sphaeralium circulorum. Poli mundi. Polorum nomenclaturae]."

116 (Sacrobosco and Fine 1516, II, sig. b2r): "De duobus coluris. [*in marg.* Quid colurus. Colurus solsticialis. Solstitium. Quid maxima solis declinatio. Colurus equinoctialis]." See also (Fine 1532, II.5, 112r): "De duobus circulis maioribus, quos coluros appellant. [*in marg.* Coluri qui dicantur circuli, et eorum officium. Colurus aequinoctiorum. Colurus solstitiorum. Qui nam arcus maximas Solis metiantur declinationes. Quid maximae declinationes polorum distantijs adaequantur]."

117 (Sacrobosco and Fine 1516, II, sig. b2r–v): "De Meridiano et orizonte circulo. [*in marg.* Quid meridianus. Longitudo regionum. Quid orizon. Rectus orizon. Orizon obliquus]." See also (Fine 1532, II.6, 112v): "De Meridiano et Horizonte circulo. [*in marg.* Meridianus circulus, unde dictus. Meridianorum diversitas. De Horizonte circulo. Horizon rectus. Horizon obliquus. Cur sphaera recta vel obliqua dicatur]."

118 (Sacrobosco and Fine 1516, II, sig. b1r–b2r): "De zodiaco circulo [*in marg.* Quid zodiacus circulus. Tria eius nomina primum. Nomina ordo et numerus signorum. Divisiones partium zodiaci. Quid linea ecliptica. Acceptiones signi]." See also (Fine 1532, II.2, 108v–09v): "De Zodiaco vel Ecliptica, atque duodecim ejusdem signis. [*in marg.* Mathematica Zodiaci descriptio. Zodiacus circulus cur ita nominatus. Zodiacus et Ecliptica idem. De zodiaci latitudine. Quod signa proprie sunt zodiaci circuli. De ordine ac initio signorum. De signorum partibus. Quadruplex signorum acceptio]."

119 (Sacrobosco and Fine 1516, II, sig. b2v): "De quatuor circulis minoribus. [*in marg.* Tropicus estivalis. Tropicus hyemalis. Circulus arcticus. Circulus antarcticus. Quae zonae sint bene habitabiles et quae male.]" See also (Fine 1532, II.7, 113v–14v): "De duobus tropicis, totidemque polaribus circulis, quinque Mundi partes (quas zonas vocant) distinguentibus. [Tropici unde ita nominati. Tropicus aestivalis, sive cancri. Tropicus hyemalis, sive Capricorni. De polaribus circulis. Quid circuli polares invicem aequales sunt et paralleli. Circulus arcticus. Circulus antarcticus. Quinque zonae coelestes. De figura et magnitudine praedictarum zonarum. Quid praefatae zonae accidentali natura differant]."

120 (Fine 1532, V.1, 141v): "De circuli atque parallelis, super conglobata Telluris et Aquae superficie respondenter imaginandis: eorumque parallelorum ratione, ad quemvis magnum circulum: Inter majores itaque circulos, quos in coelesti sphaera constituimus, sex primarij, utpote, Aequator, Meridianus, Horizon, ambo Coluri, et is qui per duorum quoruncumque locorum vertices transire diffinitur, super conglobata Telluris et Aquae superficie, veniunt respondenter imaginandi: Ex minoribus autem, duo Tropici, totidemque circuli polares…. Ut quemadmodum eorundem coelestium circulorum officio, syderum venamur habitudines: haud dissimiliter per eos, quos super ipso terrestri globo designamus, locorum positiones, atque distantias obtinere valeamus…. Manifestum est praeterea, compositam et Tellure et Aqua superficiem, in quinque regiones praecipuas, sive Zonas, figura, magnitudine, atque natura differentes (quemadmodum et coelum) respondenter separari."

Fine to present the distinction between cosmic, chronic, and heliacal risings,[121] as well as the distinction between right and oblique ascensions.[122] Book IV, which deals with the motion of the sun and its effect on the duration of daylight, tackles the inequality of natural days[123] and the difference between artificial day and night.[124]

[121] (Sacrobosco and Fine 1516, III, sig. b3v–b4r): "Capitulum tertium de ortu et occasu signorum. De diversitate dierum et noctium et de divisione climatum. [*in marg.* Diffinitio ortus et occasus. Cosmicus ortus. Cosmicus occasus. Chronicus ortus. Chronicus occasus. Heliacus ortus. Heliacus occasus.]" See also (Fine 1532, III.1): "Liber tertius Cosmographiae, sive mundi Sphaerae: de signorum et arcuum ascensionibus et descensionibus: atque syderum ortu et eorundem occasu," (118v–19v): "De vulgari syderum ortu ac eorundem occasu. [*in marg.* Generalis ortus et occasus syderum interpretatio. Ortus cosmicus. Occasus cosmicus. Ortus chronicus. Occasus chronicus. Ortus heliacus. Occasus heliacus]."

[122] (Sacrobosco and Fine 1516, III, sig. b4r–c1v): "De ortu et occasu signorum secundum astrologos. [*in marg.* De sphera recta. Oppositio signorum. Comparatio sphaerae rectae et obliquae]." See also (Fine 1532, III.2, 119v–20v): "De signorum Eclipticae, atque syderum ortu, ac eorundem occasu, qui ab Astronomis ascensio, atque descensio proprie nominantur: quae recta item vel obliqua tam ascensio, quàm descensio vocitetur. [*in marg.* Quid in ortu vel occasu syderum consyderat Astronomus. Quid ortus vel ascensio signi aut dati arcus Eclipticae. Descensio vel occasus signi vel dati arcus Eclipticae. Syderum ortus vel ascensio quid. Descensio vel occasus eorundem syderum. Signum rectè oriens. Signum obliquè oriens. Unde recta vel obliqua signorum ascensio. Quae signa rectius oriantur caeteris. Signum rectè occidens. Signum obliquè occidens. Quae signa rectius occidunt caeteris. De signorum vel arcuum partibus];" (III.3, 120v–23r): "Quaenam ascensionis atque descensionis accidentia in recto contingant Sphaerae situ: necnon de rectarum ascensionum supputatione. [in marg. De signis oppositis. Oppositio signorum. De habentibus sphaeram rectam. De obliqua sphaera]."

[123] (Sacrobosco and Fine 1516, III, sig. c1v–c2r): [Dies naturalis. De inequalitate dierum.] See also (Fine 1532, IV.1) "Liber quartus cosmographiae, sive mundi Sphaerae, De dierum et horarum tam aequalium, quàm inaequalium, et umbrarum ratione: deque singulorum accidentibus, juxta varium sphaerae situm observatis," (130v–32v): "De Die naturali. [*in marg.* Dies naturalis. Ex quibus dies naturalis integretur. Exemplum diei naturalis. Cur dies naturales sint adinvicem inaequales]."

[124] (Sacrobosco and Fine 1516, III, sig. c1v): "[De habentibus sphaeram rectam. De obliqua sphera. De diebus majoribus. De minoribus diebus. De die maxima. De minima. De diebus aequinoctialibus. De alijs diebus anni]." and (3.7–3.9): "De diversitate dierum et noctium quae sit habitantibus in diversis locis terrae; Quorum zenith est inter aequinoctialem et tropicum cancri; Quorum zenith est in tropico cancri; Quorum zenith est inter tropicum cancri et circulum arcticum; Quorum zenith est in circulo arctico. Quorum zenith est inter circulum arcticum et polum mundi. Quorum zenith est in polo arctico." See also (Fine 1532, IV.2, 132v): "De die artificiali, eiusque differentijs et calculo. [*in marg.* Unde orta diei atque noctis artificialis distincto. Dies artificialis. Nox artificialis. Cur in recta sphaera dies sint semper aequales noctibus. Quod in quavis obliquitate sphaerae, bis tantum in anno dies sint aequales noctibus. De reliquis diebus artificialibus in obliquo sphaerae situ cum noctibus semper inaequalibus. Causa majoris inaequalitatis dierum et noctium in obliqua sphaera. In quibus locis Eclipticae, dierum et noctium alternata contingat paritas. Dies aestivales. Dies brumales. Qui dies sine noctibus minores, et econtra. Ubi dierum et noctium diversitas maxima. Sub qua poli sublimitate dies naturalis continue lucidus, vel totus contingat obscurus. De diebus artificialibus diem exuperantibus naturalem. De iis quae dimidium annum lucidum et reliquum videntur habere tenebrosum]." and (IV.4, 138r–41r): "De utraque umbra, recta scilicet et versa, earumque differentis et calculo: unà cum Solarium altitudinum supputatione [*in marg.* De meridianarum umbrarum varietate. De umbris meridianis eorum qui sub Aequatore, vel inter Aequatorem et Tropicorum alterum degunt. De ijs quorum vertices sub tropicis collocantur. De ijs quorum vertex inter Tropicos et circulos polares constituitur. Ubi dies artificialis aequalis aut major 24 horis, qualis umbrarum inflectio]."

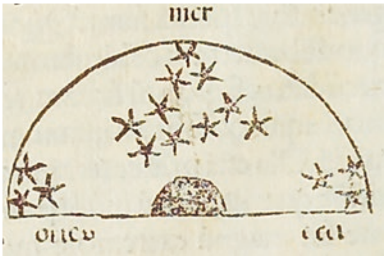


Fig. 8.2 *De caeli revolutione*. The representation of the circular motion of the stars in the Venetian incunabula editions. From (Sacrobosco et al. 1488, sig. a8v:). HAB Wolfenbüttel: 16.1 Astron

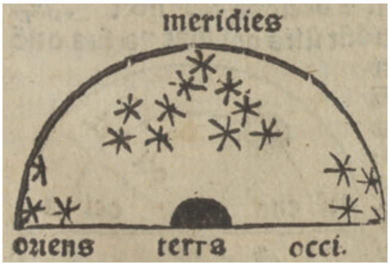


Fig. 8.3 *De caeli revolutione*. The representation of the circular motion of the stars in Fine's edition of the *Sphaera.* From (Sacrobosco and Fine 1524, sig. a3r). Courtesy of the Library of the Max Planck Institute for the History of Science, Berlin

Book V, which deals with the second main division of cosmography (geography), considers the distinction of the climates.[125] The remaining topics dealt with in book V, as well as some topics considered in books II to IV, do not belong, strictly speaking, to the list of topics considered by Sacrobosco and will be presented later.

The relation between the *Cosmographia* and the *Sphaera* is also made clear by the use of illustrations similar to those found in prior editions of Sacrobosco, notably in the editions printed in Venice in the late fifteenth century and in the early sixteenth century, to which relate some of the engravings Fine produced for his own edition of the *Sphaera* and for the *Cosmographia*, though the style of the drawing is perceptibly different (Pantin 2010).[126] Compare, for example, the illustrations in the first book of Sacrobosco's *Sphaera* in the 1488 edition—as indicated in (Chap. 9), it was the first printed edition of Sacrobosco that included the complete set of "Venetian Sacrobosco figures"—with those in Fine's edition and in the *Cosmographia* for the revolution of the heavens (Figs. 8.2, 8.3 and 8.4). In the *Cosmographia*, the engravings are both richer in detail when it comes to the representation of the ter-

[125] (Sacrobosco and Fine 1516, III, sig. c4r–d1v): "De divisione climatum [in marg. Divisio climatum. Diffinitio climatum. Primum clima. Secundum clima. Tertium clima. Quartum clima. Quintum clima. Sextum clima. Septimum clima. Quid latitudo climatis. Quid longitudo climatis]." *See also* (Fine 1532, V.2, 143v–44v): "De Parallelis Climatum distinctoribus: quonam item pacto, dato lucis arcu singulorum parallelorum, polares investigentur altitudines. [*in marg.* De parallelis climatum distinctoribus. Climatum diffinitio. Distributio climatum. De climatum magnitudine.]"

[126] On the evolution of illustration practices in Renaissance astronomical treatises, including editions and commentary on Sacrobosco, see (Gingerich 1999; Pantin 2001; Cosgrove 2007; Barker and Crowther 2013; Oosterhoff 2015).

Fig. 8.4 *De caeli revolutione*. The representation of the circular motion of the stars in the *Cosmographia*. From (Fine 1532). Augsburg, Staats- und Stadtbibliothek—2 Math 30, 105r, urn:nbn:de:bvb:12-bsb11199761-8

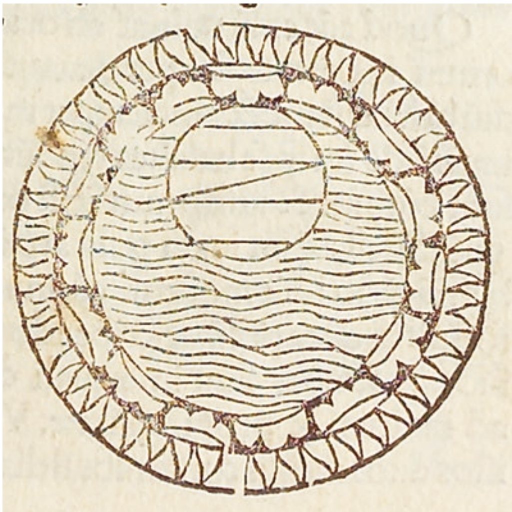


Fig. 8.5 *Quae forma sit mundi*. The disposition of the elementary spheres according to the Venetian incunabula editions. From (Sacrobosco et al. 1488, sig. a8r). HAB Wolfenbüttel: 16.1 Astron

restrial globe and of mathematical instruments,[127] and more abstract when representing the geometrical configuration of parts of the celestial sphere and the modes of computation of the positions of stars (Pantin 2010; Mosley 2009).[128] It is interesting to note here that there is a great difference between these works in the depiction of the sphere of earth when representing the mutual disposition of the elementary spheres (Figs. 8.5, 8.6 and 8.7), as, in Fine's edition of Sacrobosco (Fig. 8.6), contrary to the Venetian edition (Fig. 8.5), the spheres of earth and of water are drawn

[127] This richness of detail appears indeed also in his representation of instruments, for instance in the demonstration of the difference between *umbra recta* and *umbra versa*, where the illustration includes some form of contextualization by the presence of a human figure or a landscape in the background (Fine 1532, resp. fol. 110v, 113r, 138r). On this aspect in Fine's astronomical frontispieces, see (Pantin 2009b) and, on the visual changes made to Sacrobosco's *Sphaera* through the integration of cosmographical elements, see (Chap. 2).

[128] As shown by (Chap. 9), 15 of Fine's 1532 *Cosmographia* were taken up in the edition of Sacrobosco published in Wittenberg in 1538.

Fig. 8.6 *Divisio sphaerae mundi elementaris regio*. The disposition of the elementary spheres according to Fine's edition of the *Sphaera.* From (Sacrobosco and Fine 1524, sig. a2v). Courtesy of the Library of the Max Planck Institute for the History of Science, Berlin

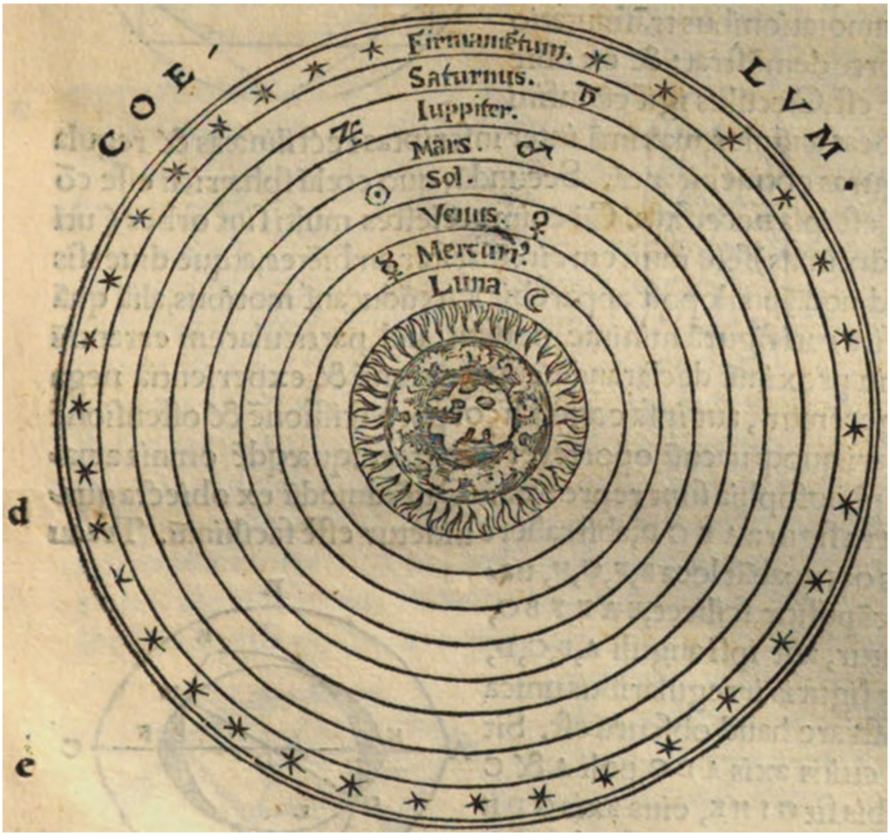


Fig. 8.7 *De coelestium orbium numero, atque positione*. The disposition of the elementary and celestial spheres according to the *Cosmographia.* From (Fine 1532). Augsburg, Staats- und Stadtbibliothek—2 Math 30, 104r, urn:nbn:de:bvb:12-bsb11199761-8

in the form of a single orb. The relative similarity with the corresponding illustration in the *Cosmographia* (Fig. 8.7), which is also found in the *Theorique des cielz* (Fine 1528, 3r), indicates that Fine then wished to introduce an updated knowledge of the relation between the spheres of earth and water. However, the representation of the nesting orbs that divide the world according to the number of planets and according to the different motions of the fixed stars is different in Fine's edition of the *Sphaera* (Sacrobosco and Fine 1516, sig. a2r) and the *Cosmographia* (Fig. 8.7), since for the former (which, on this topic, closely follows the Venetian editions of the *Sphaera*), there are nine spheres, as was taught by Sacrobosco, while for the latter there are only eight celestial spheres, according to what Fine taught in this context (as will be shown in the last section).

If the structure of Sacrobosco's treatise may be easily recognized behind the list of topics and thematic divisions of the *Cosmographia*, this treatise was still an occasion for Fine to provide an expanded and up-to-date teaching on the various topics dealt with in the *Sphaera* (Pantin 2010, 2013a; Mosley 2009)—in this, it was not so different from the various sixteenth-century editions of Sacrobosco that expanded the original text by collating it with complementary material (Crowther et al. 2015; Valleriani 2017; Pantin 2013b). It was also an occasion for Fine to offer a teaching on his practice of cartography, materialized by his own terrestrial or regional maps (Fine 1525, 1531b, 1536), some of which were produced before he was enrolled as a royal lecturer and which undoubtedly contributed to his recognition by the French court (Conley 1996, 115–32; Dupèbe 1999, II, 530, 541; Brioist 2009b; Pantin 2009a, 2010, 2013a).

In wanting to provide a modernized teaching of the sphere, Fine chose to change or leave aside several chapters he very likely judged obsolete or irrelevant to the learning required in this framework, or which simply repeated elements already taught in previous parts of the *Protomathesis*, as was the case for the preliminary definitions of the geometrical sphere by Euclid (3rd century BCE) and Theodosius (ca. 160–ca. 100 BCE), which Sacrobosco included at the beginning of the first book and which Fine had presented beforehand in the geometrical part of the *Geometria libri duo*.[129] He also left aside the distinction between the division of the sphere

[129] (Fine 1532 (*Geometria libri duo*), 53v): "solidas figuras, primum sese offert Sphaera, omnium regularissima: hoc modo diffinienda. Sphaera est corpus solidum, regulare, unica superficie terminatum: in cujus medio punctum assignatur, centrum eiusdem adpellatum, à quo ad ipsam orbicularem et terminativam superficiem, omnes quae ducuntur rectae lineae sunt invicem aequales…. Imaginatur autem describi Sphaera, ex completo semicirculi circunductu: cum videlicet semicirculi diametro manente fixo, ejusdem circuli plana superficies abstractivè circunducitur, quatenus unde ferri ceperat revertatur." (Sacrobosco and Fine 1516, sig. a2r): "Sphera igitur ab Euclide sic describitur. Sphera est transitus circumferentie dimidii circuli que fixa diametro quousque ad locum suum redeat circumducitur. Id est Sphera est tale rotundum et solidum quod describitur ab arcu semicirculi circumducto. Sphaera etiam a Theodosio sic describitur. Sphaera est solidum quoddam una superficie contentum in cuius medio est punctus a quo omnes lineae ductae ad circumferentiam sunt aequales. Et ille punctus dicitur centrum sphaerae." It should be noted that, contrary to the order found in Sacrobosco, Fine first presented the definition of the sphere by Theodosius, which defines the sphere by its spatial properties, and then the definition of Euclid, which on the contrary defines the sphere by its mode of generation. Such order is also found in later commentar-

according to substance (*secundum substantiam*) and according to accident (*secundum accidens*), which was probably due to the fact that such a distinction would be tacitly expounded afterwards when dealing with the composition of the heavens[130] and when appealing to the distinction between right and oblique horizons.[131]

As in the other cosmographical treatises mentioned above, the part concerning the theory of the planets was completely left aside, with the exception of the theory of the sun, which was then integrated into the chapter on natural and artificial days. The fact that the motion of the planets is not dealt with in this context was very likely due to its belonging to a different section of the teaching of astronomy within the traditional mathematical curriculum (Barker 2011; Valleriani 2017). Fine, in the division of astronomy he presents in the preface of the first edition of his *Cosmographia*, implicitly points out that, although the theory of the sphere and the theory of planetary motions both belong to the same type of knowledge (mathematical or theoretical astronomy), they represent distinct subdivisions of this teaching, the theory of the sphere representing the first part and the theory of planetary motions, the second part.[132] Thus, for Fine (in accordance with the common model for the teaching of astronomy in medieval and Renaissance faculties of the arts), if spherical astronomy could be taught independently from planetary theory, the teaching of planetary motions required at least a basic understanding of the theory of the sphere, as shown by his *Theorique des cielz*, in which he included a general description of the cosmos, which was absent from the original text of Peurbach's *Theorica planetarum.*[133] In the *Cosmographia*, Fine also left aside the section dealing with eclipses presented by Sacrobosco in the fourth chapter, whose absence in

ies on Euclid's *Elements*, for instance, in those of François de Foix-Candale or Henry Billingsley, in which was clearly enunciated the distinction and hierarchization between essential definitions and genetic definitions of geometrical objects, adequately illustrated by the difference between Theodosius and Euclid's respective definitions of the sphere (Euclid 1566, 140r–v; Euclid 1570, 315v). This distinction is also made in the medieval commentaries of Sacrobosco, for instance, in Pierre d'Ailly's *Quaestiones* (Sacrobosco et al. 1531, 146v), who argued that the Euclidean definition was less proper than the definition of Theodosius to define the sphere, since it defined it by one its accidental features (the motion by which it is produced) rather than by one of its essential features (its spatial properties).

130 (Fine 1532 (*Cosmographia*), I.3, 103v–104v): "De coelestium orbium numero, atque positione."

131 (Fine 1532, II.6, 112v): "De Meridiano et Horizonte circulo. [*in marg.* Horizon rectus. Horizon obliquus. Cur sphaera recta vel obliqua dicatur]."

132 (Fine 1532, 102v): "Theoricae…. Astronomiae duplex habetur consyderatio. Aut enim primi tantum et universalis est motus: aut particularium orbium, peculiari et indefessa latione ductorum. At si primi tantummodo, et universalioris motus fiat observatio: haec universalior erit, multiplicem, cum numerum, tum coelestium corporum agitationem, signorum ascensus et descensiones, dierum et umbrarum incrementa et diminutiones, geographica omnia, et reliqua ejuscemodi ex eadem prima et regulata totius Universi circunductione, inferioribus accidentia concernens." (Fine 1542b, 5v): "Est enim Cosmographia, Mundanae structurae generalis ac non injucunda descriptio: prima Astronomiae partem."

133 Peurbach's treatise starts directly with the sun's *theorica*; (Peurbach and Fine 1515, 2v): *De Sole*. "Sol habet tres orbes a se invicem omni quamque divisos atque sibi contiguos…."

this context is less expected, as eclipses related to the theory of the motion of the sun and were necessary at the time for the calculation of longitudes, as indicated in the third chapter of book V.[134]

Fine also expressed strong reservations in the second book concerning the various geometrical representations or divisions of the twelve zodiacal signs which are described in the *Sphaera* (Sacrobosco and Fine 1516, sig. b1v-b2r),[135] stating that these imaginary representations are not only fictitious and useless, but also entirely alien to the contemplation of the mathematician.[136] He furthermore manifested the will, in the third book, to distance himself from the literary approach adopted in the *Sphaera*, where ancient Roman authors (Virgil, Ovid, Lucan) are regularly quoted. As already mentioned, he criticized this approach as violating the mathematical purity of the teaching of the sphere[137] and thus clearly positioned himself on this aspect against the form and style of Sacrobosco's teaching of astronomy.[138] The authors he referred to (ancient and modern) in this context are indeed mostly mathematicians, astronomers, and philosophers: Aristotle, Euclid, Eratosthenes (ca. 276–ca. 195 BCE), Ptolemy, al-Farghānī,[139] al-Battānī (850–929), Averroës (1126–1198), Abraham ibn Ezra (1089–ca. 1167), Campanus of Novara (ca. 1220–1296), Alfonso X of Castile (1221–1284), Nicolas of Cusa (1401–1464), Georg Peurbach, Johannes Regiomontanus, Johannes Werner (1468–1522), Albert Pigghe (1490–1542), and Agostino Ricci (1512–1564). The absence of Sacrobosco's name, within this relatively long list of authorities, stands out all the more.

Besides the integration of new authorities, Fine made many more additions. He first of all quasi-systematically added examples to illustrate the meaning of the theo-

[134] (Fine 1532, V.3, 145v): "Cognoscitur autem ipsa longitudinalis duorum quoruncunque locorum differentia, per eiusdem Lunaris eclipsis in utroque loco factam observationem."

[135] The various regions encompassing the zodiacal constellations of stars would be represented either as the twelve rectangular divisions of the zodiacal belt, each measuring thirty degrees wide and twelve degrees high; or as the twelve pyramids whose bases are the aforementioned rectangular divisions of the zodiacal belt and whose vertices coincide with the centre of the universe; or as the twelve regions obtained by dividing the outer surface of the worldly sphere by six great circles passing by the beginnings of the signs; or otherwise as the twelve wedges obtained by the division of the whole body of the world by the afore-mentioned six great circles and which all extend to the axis of the zodiac.

[136] (Fine 1532, II.2, 109v): "Sed haec tam varia signorum imaginatio non modo fantastica, sed prorsus inutilis, et a mathematica contemplatione mihi videtur aliena. Solam enim syderum ad partes ipsius Eclipticae respondentiam, ut eorundem syderum mutua cognoscatur habitudo, motusque diversa supputetur quantitas, observare solemus."

[137] (Fine 1532 (*Cosmographia*), III.1, 119v): "Hoc demum triplici et vulgato syderum ortu et occasu, poetae frequentius uti solent: utpote, qui circuitiones tantummodo consyderant, ad discernenda videlicet anni tempora. Uti videre licet ex Virgilio, Ovidio, Lucano, et caeteris ejuscemodi. Quorum exempla dare, esset mathematicam violare puritatem."

[138] This may be contrasted with the opposite approach of André do Avelar, who did not only avidly quote the ancient authors cited by Sacrobosco (Lucan, Ovid, and Virgil), but also added supplementary quotations from these authors and others (Chap. 10). On the literary use of Sacrobosco's *Sphaera*, see (Oosterhoff 2015).

[139] The five latter were also referred to in the *Sphaera*.

retical and practical teaching he provided. These examples, which are present throughout the five books of the *Cosmographia*, often consist of commented figures, showing, for example, the position of a star in relation to the equinoctial or the ecliptic in order to explain its mode of calculation. When a computational procedure is taught, numerical examples are used.

Fine also completed or reassessed some of the notions dealt with by Sacrobosco in the *Sphaera* by comparing, for example, the notions of declination and right ascension with the notions of latitude and longitude of stars and their respective relations to the celestial equator and to the ecliptic in chapter 3 of book II.[140] He furthermore added various chapters and subsections containing practical material (which, however, maintain an overall theoretical scope),[141] pertaining, for instance, to the positioning of stars, to the measurement of the altitude of the sun, as well as to judicial astrology,[142] as Jacques Lefèvre d'Étaples had done in his commentary on Sacrobosco's *Sphaera* (which Fine contributed to reprint in 1521) (Chap. 2). These additional elements did not necessarily bring forth new knowledge and, for some, were mainly meant to offer complementary or up-to-date information required by the practice of astronomers and cartographers on the basis of concepts enunciated in Sacrobosco's *Sphaera*.[143] For instance, a few of the tables provided by Fine are similar to those found in Lefèvre's commentary on Sacrobosco, although the format and the compiled data (which Fine claims to have computed himself) are slightly different.[144]

In chapter II.4, Fine presented the means to find the declination of the ecliptic for any degree of the equinoctial.[145] He then also described the mode of fabrication and

140 (Fine 1532 (*Cosmographia*), II.3, 109v): "Quidnam sit declinatio et latitudo syderum, atque de ratione declinationis Zodiaci ab Aequatore: Declinatio est arcus circuli magni, per Mundi polos, et datum astrum, vel coeli punctum educti: inter Aequatorem, et ipsum astrum, sive punctum compraehensus. Latitudo verò, est arcus magni itidem circuli, sed ex polis Eclipticae, per datum sydus, aut signatum in coelo punctum transeuntis: qui inter ipsum sydus, vel idem punctum, et Eclipticam capitur."

141 Adam Mosley makes it clear that, although Fine offered various elements pertaining to practical mathematics in this context, notably instructions on how to perform certain procedures, even on how to make instruments (often expressed in the second-person singular imperative), these remain of a theoretical nature (Mosley 2009).

142 On these additions, see also (Mosley 2009; Pantin 2010).

143 See the title of the 1542 unabridged edition: "De Mundi Sphaera, sive Cosmographia, primáve Astronomiae parte, Libri V: Inaudita methodo ab authore renovati, proprijsque tum commentarijs et figuris, tum demonstrationibus et tabulis recens illustrati."

144 Compare for instance (Fine 1532, III.3, 122v) and (Sacrobosco and Fine 1538, 17v), in the 1538 reprint of Fine's edition of Lefèvre's commentary on Sacrobosco or (Fine 1532, III.4, 126r) and (Sacrobosco and Fine 1538, 18r). Fine's tables are presented further. Richard Oosterhoff (Oosterhoff 2018, 149–150) considered that Fine wrote the *Cosmographia* in order to replace Lefèvre's commentary on Sacrobosco's *Sphaera* (Sacrobosco et al. 1495). This would confirm that Fine's main model for the introduction of numerous practical elements in his teaching of spherical astronomy (tables and computation techniques) was this commentary by Lefèvre, which, as said, he reedited in 1521. Moreover, this would confirm that, in writing the *Cosmographia*, Fine consciously placed his work in the tradition of Sacrobosco's *Sphaera*.

145 (Fine 1532, II.4, 110v): "Ut maxima Solis, vel Eclipticae declinatio et reliquae singulorum punctorum eiusdem Eclypticae declinationes inveniantur."

the use of the quadrant to measure the altitude of the sun and provided a table for the declination of the sun, along with the instructions on how to compute and use it.[146] After dealing with the celestial circles taught in Sacrobosco's second book, he introduced, in chapters 8 and 9 of book II, circles relating to the horizontal positioning of the viewer—namely, the perpendicular and parallel circles that divide the sphere according to the horizon (verticals and circles of altitude)[147] and the circles of hours and their role in the constitution of sundials.[148] Chapter 10, which is the last of book II, deals with the astrological division of the heavenly sphere into twelve houses, where Fine compared the modes of distinction of the celestial houses adopted respectively by Campanus and by Regiomontanus, as well as its application to the astrological chart.[149]

In chapter 3 of the third book, Fine introduced instructions on how to compute the ascensions of the parts of the ecliptic in the right sphere for each degree of the equator from the vernal equinox,[150] along with the corresponding table.[151] Similar material is given in the chapters III.4 and III.5 for the computation of the arcs of

[146] (Fine 1532, II.4, 110v–11v): "[*in marg.* Instrumenti constructio, quo maxima declinatio Solis observatur. Maxima Solis declinatio, qualiter per idem observetur instrumentum…. Ut reliquorum Eclipticae declinatio supputetur. De componenda tabula declinationis. Usus tabulae succedentis];" (111v): "Tabula declinationis solis, praesupponens maximam eius declinationem 23 gra. et 30 mi. per Authorem supputata 1530."

[147] (Fine 1532, II.8, 114v): "De verticalibus, atque altitudinum circulis: Praeter hos autem supra descriptos sphaerae circulos, varia reperitur in eadem sphaera aliorum circulorum imaginatio: de quibus consequenter tractare commodissimum existimamus. utpote, à quibus bona pars ipsius Astronomiae, ac universa ferè coelestium instrumentorum et theorica et practica pendere videtur. Inter quos primum sese offerunt, qui dicuntur verticales: et ij, quos altitudinum solemus appellare circulos. Sunt igitur verticales circuli, qui ex dati cuiuslibet loci vertice, in singulas Horizontis partes deducuntur: et supernum hemisphaerium in tot partes quot et Horizontem undiquaque distribuunt…. Altitudinum verò circuli sunt, qui circa locorum verticem parallelicè describuntur, et cuiuslibet verticalis circuli distribuunt, et vicissim ab eisdem verticalibus circulis, in 360 partes, sive gradus, sigillatim dividuntur: quorum primus, et omnium maximus est Horizon, minimus verò, qui propior est vertici."

[148] (Fine 1532, II.9, 115v): "De circulis horarum distinctoribus. Non prorsus aspernandam consequenter judicamus horarium circulorum designationem: ab ipsis enim universa, tum horarum, tum solarium horologiorum ratio potissimum deducitur."

[149] (Fine 1532, II.10, 116v–17v): "Quibus circulis 12 coeli partes (quas vocant domos) separentur: atque de circulo positionis appellato. De circulis tandem coelestium domiciliorum distinctoribus, variae inter Astronomos reperiuntur opiniones; Figura generalis 12 coelestium domiciliorum secundum judiciarios Astrologos." Though he recognised the benefits of the division of Regiomontanus, he recommends his readers to follow Campanus: (Fine 1532, 117v): "Si meo tamen stare velis judicio a via Campani non discedes: multo siquidem fideliora, cum probatissimus Astrologis poteris elicere judicia." On the different modes of distinction of the sphere in 12 astrological houses, see (Bezza 2014).

[150] (Fine 1532, III.3, 120v): "Quaenam ascensionis atque descensionis accidentia in recto contingant sphaerae situ, necnon de rectarum ascensionum supputatione;" (121v): [*in marg.* Canon supputationis rectarum ascensionum cuiuslibet arcus Eclipticae].

[151] (Fine 1532, III.3, 122v): "Tabula rectarum ascensionum singulorum arcuum Eclipticae, ab Ariete gradatim initiatorum, per Authorem supputata."

ascension of the ecliptic in the oblique sphere, calculated for the latitude of Paris,[152] which includes a table of the ascensional differences between the arcs of the zodiacal signs in the right and oblique spheres,[153] as well as tables for the oblique ascensions of the signs for the latitudes of 48°40′ on the northern and southern hemispheres for each degree of the equator,[154] as well as corresponding tables for the total ascensions of each sign for the same latitudes.[155] Fine then also provided a table for the oriental and occidental latitudes of the rising and setting of the arcs of the ecliptic (and thus of the sun) for the latitude of Paris.[156] In this fifth chapter of book III, he also added a part on the determination of the rising degree of the ecliptic, also called the ascendant or the horoscope,[157] and of the beginnings of the remaining astrological houses, according to the methods of Campanus and of Regiomontanus.[158]

In the fourth book, when dealing with the inequality of natural days, Fine replaced Sacrobosco's discourse on the annual spiral motion performed by the sun along the ecliptic in the course of a year by the theory of the sun's motion found in Peurbach's *Theorica planetarum.*[159] The aim of this teaching, as Fine put it, is to

[152] (Fine 1532, III.4, 123r): "De ascensionum atque descensionum accidentibus in obliquo sphaerae situ contingentibus: quonam item modo obliquae supputentur ascensiones." (124v): [*in marg.* De ratione supputationis obliquarum ascensionum].

[153] (Fine 1532, III.4, 125v): "Tabula differentiarum ascensionalium, ad elevationem poli arctici 48 gra. et 40 mi. per Authorem supputata."

[154] (Fine 1532, III.4, 126r): "Tabula ascensionum obliquarum, ad elevationem poli arctici 48 gra. et 40 mi. per Authorem ab Ariete gradatim supputata" and (126v): "Tabula ascensionum obliquarum, ad elevationem poli antarctici 48 gra. et 40 mi. per Authorem ab Ariete gradatim supputata."

[155] (Fine 1532, III.4, 127r): "Tabella obliquarum ascensionum et descensionum cujuslibet signi per sese consyderati, ad elevationem poli arctici 48 gra. et 40 mi. seorsum extractarum" and (127v): "Eadem obliquarum ascensionum atque descensionum tabella, ad eandem, sed poli antarctici sublimitatem calculata."

[156] (Fine 1532, III.5, 127v): "Quid sit ortus vel occasus latitudo, qualiter praeterea ad liberam quamvis obliquitatem sphaerae…;" (128r): [*in marg.* Ortus latitudo in obliqua sphaera, qualiter supputanda]; 128v: "Tabula latitudinis ortus, ad elevationem poli arctici 48 gra. et 40 mi. [*in marg.* De usu tabulae latitudinis ortus]."

[157] (Fine 1532, III.5, 128v–129v): "Quid sit ortus vel occasus latitudo, qualiter praeterea ad liberam quamvis obliquitatem sphaerae, unà cum ascendente Eclipticae gradu supputetur: ubi de supputandis coelestium domorum initijs notanda digressio. [*in marg.* De supputando ascendente gradu eclipticae. De supputanda ascendentium tabula]."

[158] (Fine 1532, III.5, 130r): [*in marg.* Initia 12 domorum qualiter, secundum viam Campani, veniant supputanda. Alius modus ad idem; juxta modum Joannis Regiomontani].

[159] Compare, for example, the following passages: (Fine 1532, IV.1, 131r): "Ut autem universa dierum naturalium discrimina, et mediocrum ad veros dies, aut econtra, reductionem concipere facile possis: theoricam motus ipsius Solis, ad salvandam, supputandamque motus eiusdem Solis circa Mundi centrum observatam irregularitatem subtiliter excogitatam, hoc loco perstringere libet…. Imaginantur itaque prudentiores Astronomi, solarem orbem in tres adinvicem contiguos orbes separari…" See also (Peurbach and Fine 1515, 2v): *De Sole*. "Sol habet tres orbes a se invicem omni quamque divisos atque sibi contiguos…;" (Fine 1532, 131v): "Fingunt praeterea, circa idem centrum eccentrici, circulum quendam, partem Eclipticae itidem eccentricum nominatum, cujus circunferentia per centrum Solis transire diffinitur…. In hunc porro circulum eccentricum procedentium ex Mundi centro rectarum linearum, maxima est in qua centrum eccentrici…et lon-

help understand the difference between natural days and show how to obtain the true motion of the sun from its mean motion and vice versa.[160] In this part, he used the illustration of the sun's motion which he engraved for his *Theorique des cielz* (Fine 1528; Pantin 2010).[161] However, this part is not a full substitution, since in the next chapter (chapter IV.2) he resorted to Sacrobosco's description of the daily parallel circles obtained from the annual spiralling of the sun from one tropic to the other to describe the differences between day and night in the right and oblique spheres (Fine 1532, 133v–34r). In this chapter, Fine taught the means by which astronomers determine the lengths of artificial days and nights for each degree of the ecliptic for any latitude,[162] providing a table of the lengths of artificial days for the latitude of Paris,[163] as well as the means to calculate the duration of the longest artificial day for each degree of latitude from the equator to the North Pole, along with a corresponding table.[164]

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gior ob id vocatur longitudo, apogium sive augem eiusdem indicans eccentrici: minima vero reliqua…, quae longitudo brevior respondenter appellatur, et perigium, hoc est, punctum apogio, vel augi denotat oppositum…." See also (Peurbach and Fine 1515, 8v–9v): "Imaginamur autem in sole eccentricum circulum per lineam a centro eccentrici usque ad centrum solare euntem: super centro eccentrici regulariter motam una revolutione facta describi: qui semper est pars superficiei eclyptice orbis signorum octave sphaere. Aux solis in prima significatione sive longitudo longior est punctus circumferentie eccentrici maxime a centro mundi remoto. Et determinatur per lineam a centro mundi per centrum eccentrici utrinque ductam: quae linea augis dicitur. Oppositum augis sive longitudo propior est punctus circumferentie eccentrici maxime centro mundi propinquus et semper augi diametraliter opponitur. Longitudo media est punctus circumferentie inter augem et oppositum augis…;" and (Fine 1532, 131v): "Orbis vero medius, deferens Solem appellatus, circa proprium centrum et axem, secundum ordinem signorum (praeter diurnum, et supradictorum orbium motum) regulariter circumfertur: ita ut Sol de circumferentia proprij eccentrici 59 minuta, et 8 fere secunda partis quotidie perambulet." See also (Peurbach and Fine 1515, 7v): "Sed orbis solare corpus deferens motu proprio super suo centro secundum eccentrici regulariter secundum successionem signorum quottidie lix minutis et octo secundis fere de partibus circunferentie per centrum corpis solaris una revolutione completa descripte movetur."

160 (Fine 1532, IV.1, 131r): "Ut autem universa dierum naturalium discrimina, et mediocrum ad veros dies, aut econtra, reductionem concipere facile possis: theoricam motus ipsius Solis, ad salvandam, supputandamque motus eiusdem Solis circa Mundi centrum observatam irregularitatem subtiliter excogitatam, hoc loco perstringere libet…." This section is maintained in the 1542 unabridged version (Fine 1542a, 48v–50v), where it is described as a *Digressio notanda*, but not in the later versions.

161 Compare (Fine 1528, 16r) and (Fine 1532, 131v). As mentioned earlier, Fine also appealed, for his edition of Sacrobosco, to images drawn from his 1516 edition of the *Theorica*.

162 (Fine 1532, IV.2, 132v): "De die artificiali, ejusdemque differentijs, et calculo;" (134v) [in marg. Qualiter supputanda dierum artificialium magnitudo, ad quamvis poli sublimitatem complemento maximae declinationis solaris minorem…. Arcum diurnum aliter supputare].

163 (Fine 1532, IV.2, 135r): "Tabula maximarum dierum artificialium, ad elevationem poli arctici 48 graduum et 40 minutorum, et singulos Eclipticae gradus, per authorem fideliter supputata."

164 (Fine 1532, IV.2, 135v): [*in marg.* Alia maximarum vel minimarum dierum supputandi ratio. De supputando maximo lucis arcu, seu continuatae lucis tempore, ad quamvis poli sublimitatem complemento maximae Solis declinatio majorem…]; (136r): "Tabula maximarum dierum artificialium, ab Aequatore circulo, ad polum usque arcticum, gradatum per authorem supputata."

The third chapter of Book IV considers the distinction between the equal and the unequal hours that divide artificial days and nights according to the latitude of the viewer and shows how to calculate the length of unequal hours for the latitude of Paris, as well as how to reduce unequal hours to equal hours and vice versa.[165] Fine also explained at this occasion the correspondence between the planets (and their rising in the first hour of the artificial day) and the names of the days of the week (Saturn on Saturday, the sun on Sunday, etc.), which he represented through a little table also indicating the planets ruling the first hour of the night, as well as the means to determine the planets ruling the other planetary hours for any day of the week.[166]

In chapter IV.4, which deals with the altitude of the sun and with the shadows produced by the sun for different parts of the world, Fine explained the distinction between *umbra versa* and *umbra recta*, and introduced the means to compute the lengths of shadows with the help of the geometrical square (*quadratum geometricum*) placed on the back of planispheres or astrolabes,[167] which he complemented with a corresponding table indicating the lengths of shadows according to the altitude of the sun.[168] He also taught the means to calculate the elevation of the sun at a given place,[169] along with a table indicating the altitude of the sun for the latitude of Paris at each hour of the day throughout the year.[170]

In book V of the *Cosmographia*, as noted above, Fine taught the principles of geography, hydrography, and chorography in the tradition of Ptolemy's *Geography* (Brioist 2009b) and according to the previously mentioned cosmographical projection onto the terrestrial globe of the celestial circles and zones described in the

[165] (Fine 1532, IV.3, 136r): "De Horis tam aequalibus quàm etiam inaequalibus." (137r–v): [*in marg.* Diurnae vel nocturnae et inaequalis horae quantitatem invenire…. De mutua horarum conversione. Inaequales horas, ad aequales reducere…. Aequalium ad inaequales conversio…. Ut vulgares horae convertantur in astronomicas].

[166] (Fine 1532, IV.3, 136v): [*in marg.* Planetam quamlibet horarem temporali diei, vel noctis artificialis dominantem invenire]. and Planetam dominans hora prima. Successio planetarum, pro reliquis horis à prima, tam diei quàm noctis artificialis (table).

[167] (Fine 1532, IV.4, 138r–v): "De utraque umbra, recta scilicet et versa, earumque differentis et calculo: unà cum Solarium altitudinum supputatione [*in marg.* Umbrae diffinitio. Umbra recta. Umbra versa];" (140v): "…quadratum…geometricum…, planisphaerio atque caeteris instrumentis inscribi solitum: quo duce, per alterutrius umbrae intersectionem, rerum altitudines, planicies, et profunditates, hoc est, omnem longitudinem elevatam, jacentem, vel depressam proportionaliter emetimur." See also (Fine 1551a, 43r): "Hinc tractum esse videtur quadratum illud geometricum, quod tum in quadrantibus, tum in Astrolabiorum dorso figuratur."

[168] (Fine 1532, IV.4, 137v): (138v–39v) [*in marg.* Ex Solis altitudine data utriusque umbrae perscrutari longitudinem. Idem per umbrarum absolvere tabulam…]; (139r): "Tabulae utriusque umbrae, rectae scilicet et versae, in partibus qualium umbrosum est 12: ad singulos gradus Solaris altitudinis, per Authorem exactè supputata."

[169] (Fine 1532, IV.4, 139v): [*in marg.* Eandem Solis altitudinem generaliter supputare…. Ut meridiana Solis altitudo colligatur].

[170] (Fine 1532, IV.4, 140r): "Tabula elevationum solis, seu locorum eiusdem in Ecliptica, qualibet hora diei artificialis, Ad poli sublimitatem 48 graduum et 40 minutorum, per Authorem fideliter supputata."

second book of Sacrobosco's *Sphaera.* This book also includes the theory of the climates and the ancient and modern distinctions of winds. Chapter V.1 considers in particular the various circles projected onto the terrestrial globe with the addition of the 89 parallels that divide each hemisphere of the terrestrial globe horizontally at one degree intervals from the equator and which enable, by their intersection with the meridians, to determine the longitudinal and latitudinal coordinates of the various places on earth.[171] For this, Fine provided a table indicating the circumference of a quadrant for each parallel in degrees of the equator and the quantity of their respective longitudinal degrees in minutes and seconds of arc.[172] Chapter V.2 properly deals with the theory of the climates, presenting the twenty-four parallels that enable one to distinguish them. In this context, Fine criticized the distinction of seven climates found in Sacrobosco's *Sphaera* and in earlier teachings on the sphere, which he attributed to the limited knowledge of their authors concerning the boundaries of the habitable world.[173] He then gave instructions on how to calculate the height of the pole from the given length of the artificial day for each degree starting from the equator[174] and a table indicating the distance from the equator of each parallel delimiting the beginning and the end of a climate zone, as well as the corre-

[171] (Fine 1532, V.1, 141v): "Inter majores itaque circulos, quos in coelesti sphaera constituimus…. Unà cum singulis datorum quoruncumque locorum parallelis, per ipsa quidem loca liberè, gradatimve ab Aequatore distributis. Ut quemadmodum eorundem coelestium circulorum officio, syderum venamur habitudines: haud dissimiliter per eos, quos super ipso terrestri globo designamus, locorum positiones, atque distantias obtinere valeamus."

[172] (Fine 1532, IV.4, 143r): "Tabula demonstrans rationes aequatoris, seu magni cujusvis, ad singulos parallelos, ab eodem Aequatore, versus utrumque polorum ipsius Mundi, gradatim distributos. Primo, in partibus, qualium Aequatoris quadrans perhibetur esse 90. Secundo, in partibus, qualium unus gradus ejusdem Aequatoris est 60."

[173] (Fine 1532, V.2, 143v–44v): "De parallelis Climatum distinctoribus: quonam item pacto dato lucis arcu, singulorum parallelorum polares investigentur altitudines;" (143v): "Quanquàm autem haec Climatum excogitatio à vulgaribus Geographis in septenarium redacta sit numerum: nihilominus tamen ab Aequatore versus utrunque Polum, et usque ad eo parallelos, ubi Sol ad diei naturalis quantitatem semel in anno sinè nocte luscescit, 24 sunt annumeranda;" (144r–v): [*in marg.* Propter quid 7 tantummodo à vulgaribus Geographis, sint ordinata climata. De peculiari climatum nomenclatura. Exemplaris 7 vulgarium climatum descriptio. Qualis vera climatum distributio. Quot sint climata, secundum veram imaginationem]. On the transformation of the theory of climates in the sixteenth century, see (Cattaneo 2009; Leitão and Almeida 2012; Almeida 2017; Valleriani 2017) (Chap. 7). It should be noted, however, that the only diagram that accompanies this chapter presents the ancient division of the climates, and not the modern division, as the later editions from 1551 on would do. Interestingly, the representation of the terrestrial globe in these earlier diagrams that present the seven climate division is more realistic (representating the seas and continents) than in the later diagram that presents the 24 climate theory, which is, on the other hand, closer in style to the more abstract diagram presenting the climates in the Venetian editions of Sacrobosco (for instance, Sacrobosco et al. 1488, BB10r).

[174] (Fine 1532, V.2, 144v): [*in marg.* Ortivam cuiuslibet eclipticae puncti latitudinem, aliter quam superius calculare…. Data Solis declinatione, et amplitudine ejus ortiva: polarem elicere sublimitatem…. Qualiter poli sublimitas investigetur, ubi dies aestivus maximus diem excedit naturalem].

sponding maximum length of artificial days.[175] This table also indicates, for comparison, the situation of the seven climates of the earlier tradition of the sphere (*7 vulgaria climata*).

In the third chapter of book V, Fine taught the geographical notions of longitude and latitude of terrestrial places, as well as the notions of longitudinal and latitudinal differences, along with their means of calculation through lunar eclipses.[176] He then provided a table of the longitudes and latitudes of various cities in France, Germany, the Italian peninsula, Spain, Sicily, Sardinia, Corsica, Ireland, Scotland, and England.[177] Chapter V.4 teaches how to measure the distances between places and the correspondence between the distances measured in terrestrial units of lengths (in paces, miles, leagues, and stadia) and in degrees of great circles, using the method given by Ptolemy in his *Geography*.[178] In the fifth chapter, Fine taught the means to measure the distance between two places from their respective longitudes and latitudes.[179] The following chapter deals with the hydrographical distinction and classification of winds, ancient and modern, into twelve and thirty-two different winds, respectively, which Fine represented through compass roses, as well as through a small table for the ancient distinction comparing the Latin and Greek names of the twelve winds.[180] In the chapter V.7, which is also the very last

[175] (Fine 1532, V.2, 145r): "Tabula polarium altitudinum seu distantiarum ab Aequatore singulorum parallelorum, pro maximarum dierum artificialium quantitate ab eodem Aequatore distributorum: per authorem fideliter supputata."

[176] (Fine 1532, V.3, 145v): "De longitudine, atque latitudine locorum: qualiter praeterea tam longitudo, quàm etiam latitudo sit investiganda;" (146r–v): [*in marg.* Qualiter ex eadem eclipsi Lunari duorum locotum longitudinalis elicitur differentia. Quidnam sit dati cuiuslibet loci latitudo. Latitudinis duorum locorum differentia. Data altitudine Solis meridiana unà cum eius declinatione, latitudinem loci concludere. Idem per stellas fixas quae oriuntur et occidunt respondenter absolvere. Eandem loci latitudinem, per stellas semper apparentes colligere].

[177] (Fine 1532, V.3, 147r–48v): "Tabula longitudinum ab occidente, atque latitudinum ab Aequatore, insigniorum locorum, civitatum et oppidorum, per saniores nostrae melioris Europae regiones constitutorum, Ab Authore recenter verificata." For the list of coordinates Fine takes up from Ptolemy, at least for his map of France, see (Gallois 1918; Dainville 1970; Broc 1983; Conley 1996, 81–110; Pelletier 2009, 13).

[178] (Fine 1532, V.4, 148v): "Quantum itineris respondeat uni gradui, vel ipsi toto maximo terrestri circulo: ut etiam locorum itinerariae metiri debeant profectiones;" (149r): [*in marg.* Quantum itineris capiat unus gradus Meridiani per similium segmentorum observatam respondentiam elicere…. Quantum uni gradui respondeat in Terra, secundum Ptolemaeum. Quantum universus terrestris ambitus per eundem Ptolemeum. Quod directa locorum itinera fieri debeant super magni circuli segmentum demonstratio].

[179] (Fine 1532, V.5, 149v): "Quonam pacto duorum quoruncunque locorum longitudinibus atque latitudinibus datis, eorundem locorum viatoria metienda sit elongatio;" (150r–51r): [*in marg.* De locis sub eodem Meridiano, et in eadem Mundi parte constitutis…. Locorum sub eodem parallelo consistentium, qualiter viatoria metienda sit elongatio…. Qualiter directum itineris intervallum, duorum locorum sub diversis Meridianis, atque parallelis constitutorum supputetur…. De locis in diversa Mundi parte ab Aequatore constitutis. Quae sub eodem Meridiano. De locis sub varijs Meridianis et parallelis inaequaliter ab Aequatore distantibus collocatis. Quando loca ipsa sub oppositis consistent parallelis. De finali arcuum milliariorum, et leucarum inventione].

[180] (Fine 1532, V.6, 152r): "De numero, situ, atque ordine ventorum, ad hydrographiae cognitionem potissimùm spectantium." (152r–53r): [*in marg.* De numero, ordine, atque positione ventorum

chapter of the *Cosmographia*, Fine presented the cartographical procedures necessary to produce regional maps (chorography), which he illustrated through a delineation of the French borders on a coordinate grid indicating the location of Paris, as well as various projection techniques drawn from Ptolemy's *Geography* for the mapping of an eighth or a half of the terrestrial globe (Brioist 2009b).[181]

As noted by Adam Mosley, Fine's geographical doctrine in the *Cosmographia* does not convey the will to present the new world discoveries, as did, on the contrary, the cosmographies of Apian (Apian 1540), Waldseemüller (Waldseemüller and Ringmann 1907) or Sebastian Münster (1488–1552) (Münster and McLean 2016; Mosley 2009).[182] This is all the more peculiar in light of the fact that in 1531 Fine himself cast a *Nova et integra universi orbis descriptio* (Fine 1531b)—in parallel to preparing the *Protomathesis* for publication—which offered a cartographical representation of the known world, that is, featuring the new geographical discoveries, according to a bi-cordiform projection. Generally speaking, for a treatise of cosmography which dedicates a separate book to geography and which furthermore signals in this geographical part the heritage of Ptolemy's *Geography*, the *Cosmographia* contains very little concrete information on the actual locations and contours of the various terrestrial regions, mainly offering methodological elements for the practice of cartography and a list of geographical coordinates for European cities situated in Europe.[183] It therefore seems that Fine's doctrine on the topic, as is the case for the rest of the material examined here, mostly aimed to correct and complete the theory of the sphere transmitted by Sacrobosco and its tradition, teaching in a rather theoretical manner the principles and methods used by cosmographers to determine the location of a place on earth and to represent terrestrial regions or the entire terrestrial globe on a map.

In the *Cosmographia*, Fine therefore followed in its broad outline the structure of the teaching provided by Sacrobosco, taking up the design and style of the *Sphaera* while leaving aside its text, to provide an updated and enriched theory of the sphere. In doing so, he perfectly illustrated the openness and yet the stability of the design

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secundum veteres naturas atque philosophos…. De numero, ordine, atque positione ventorum secundum recentiores hydrographos. Qualia ventorum iuxta navigantes hodiernos nomina. Ventorum lineamenta, qualiter in Cartis hydrographicis describenda. De succendi ventorum hydrographica].

181 (Fine 1532, V.7, 154r–55r): "Qualiter tandem oblatae cujuscunque regionis, vel partis habitabilis Orbis Chorographia, ex praedictis colligenda sit: quonam item modo hemisphaerica parallelorum atque Meridianorum contextura, ad positionem locorum necessaria in plano rationabiliter extendatur;" (154r): [*in marg.* Chorographiae gallicae in aliarum exemplum descriptio. Chorographiae ex curvis lineis contextae figurationis exemplum. Ut hemisphaerica parallelorum atque Meridianorum delineanda sit contextura].

182 On the relation between the teaching of the *Sphaera* and the exposition of the new geographical discoveries, see (Chap. 7).

183 The fact that, contrary to Apian (Apian 1540, 31v–44v) or even Lefèvre (Sacrobosco and Fine 1538, 11v–13r), he restricted the list of geographical coordinates to European cities was perhaps due to the fact that he wanted to provide the information that he considered most relevant to his addressed readership.

of the *Tractatus de sphaera* in the sixteenth century, as described by Richard Oosterhoff and Matteo Valleriani (Oosterhoff 2015; Valleriani 2017). Indeed, Fine's treatise introduced elements of knowledge exterior to Sacrobosco's teaching and at times drawn from different disciplines, but which were traditionally related to the early modern teaching on the sphere and which thus fit appropriately with the thematic structure of the *Sphaera*. The knowledge Fine added to Sacrobosco's teaching of the sphere in the *Cosmographia* is drawn from practical astronomy (astronomical computation procedures), instrument-making, judicial astrology, metrical geography, and cartography. Hence, if this list of additional elements is compared with the list compiled by Valleriani (2017) of the different disciplines that were associated with Sacrobosco's text by various sixteenth-century editors or commentators, Fine's *Cosmographia* appears to be quite similar in its form and intention to later sixteenth-century editions of Sacrobosco's treatise (Crowther et al. 2015).[184]

Moreover, the position of the *Cosmographia* within the *Protomathesis* may itself be conceived as the association of the traditional teaching of the sphere with disciplines and knowledge exterior to it. Indeed, within the *Protomathesis*, which was conceived from the start as a unified compendium (Pantin 2010), each part being required to make sense of the others, the *Cosmographia* holds both a central position[185] and a role of connecting link. Practical arithmetic and geometry (theoretical and practical), which precede the *Cosmographia* among the various parts of the *Protomathesis*, are both presented as necessary for cosmography, as it requires the methods of computation, the geometrical concepts and the measurement techniques and instruments provided by practical arithmetic and geometry. This is confirmed by the numerous references made to both treatises in the *Cosmographia*,[186] as well as by the preface of the *Geometria libri duo*, where Fine asserts their necessity for the astronomical teaching that follows.[187] This also corroborates the idea presented by Fine in the prefaces of his later editions of the *Cosmographia* that the

[184] See also, for the specific case of the Spanish and Portuguese editions and commentaries on the *Sphaera*, (Chaps. 7 and 10).

[185] Its overarching importance in the *Protomathesis* is also marked by the fact that it is the only one of the four treatises to present a properly elaborate frontispiece, containing an allegorical representation of the discipline with Fine in the role of the astronomer, and that, moreover, this frontispiece appears both to introduce the corresponding treatise (the *Cosmographia*) and to introduce the whole compendium. On this frontispiece, see (Pantin 2009b).

[186] (Fine 1532 (*Cosmographia*), I.1, 102r): "Divinam coelestis rationis doctricem Astronomiam, post Arithmeticae atque Geometriae praemissa rudimenta, consequenter adgressuri;" (II.1, 108r): "Quinam sint majores, quive minores in sphaera circuli, decimo capite libri Geometriae nostrae sufficienter annotavimus;" (II.2, 109r): "quod tametsi quilibet in sphaera circulus (uti capite primo libri tertij nostrae docuimus Arithmeticae) in 12 partes invicem aequales a Mathematicis dividatur;" *ibid.*: "De signorum tandem in gradus sub divisione, et graduum in minuta, et deinceps minutorum in succedentia partium discrimina, praeallegato capite primo libri tertij nostrae Arithmeticae sufficienter tractavimus," etc.

[187] (Fine 1532 (*Geometria libri duo*), 50r): "Non incommodum judicavimus, studiose lector, post Arithmeticae praxim, insignora Geometriae tradere rudimenta. utpote, quae non modo succedentibus nostris geographicis vel astronomicis operibus, passim sese offerunt accommoda: verumetiam universo mathematicarum studio videntur admodum necessaria."

learning and mastering of astronomy is the reason why the other parts of the quadrivium (that is, arithmetic, geometry, and music) should be studied. Moreover, the *Cosmographia* is set forth as the condition and therefore as the necessary introduction to the last part of the *Protomathesis*—that is, the *De solaribus horologiis, et quadrantibus*, which deals with the art of sundials.[188] Within this general teaching program, the theory of the sphere is both clearly distinguished from geography and presented as the condition of the apprehension and representation of the terrestrial globe and of its regions. It comes across, furthermore, as a necessary introduction to the astrological interpretation of the celestial influences. The situation of the *Cosmographia* within the *Protomathesis* thus allows us to regard the teaching of practical arithmetic, geometry, and dialing—in addition to the teaching of geography, cartography, and astrology—as a body of knowledge added to and associated with the traditional teaching of the theory of the sphere or as a set of complementary notions relevant to its study and application in a variety of contexts (Valleriani 2017). This again allows us to relate the composition of the *Cosmographia*, especially in its first edition, to the early modern practice of expanding the text of Sacrobosco, as was done in its later sixteenth-century editions and commentaries (Pantin 2013b; Crowther et al. 2015; Oosterhoff 2015; Valleriani 2017); (Chap. 5).

Fine's *Cosmographia*, in spite of the fact that it never mentions Sacrobosco's name, was in any case associated with the tradition of Sacrobosco's theory of the sphere by later generations, as it was proposed as a possible alternative to Sacrobosco's *Sphaera* in certain university teaching programs, but also because some of its illustrations were taken up in later editions of the *Sphaera*, such as certain in-octavo editions presented by Pantin in this volume (Chap. 9).

5 Cosmology in the *Sphaera* and in the *Cosmographia*[189]

Beyond the similarities and differences between Fine's *Cosmographia* and Sacrobosco's *Sphaera* with respect to their content and thematic structure, an important point of comparison is their respective representations of the cosmos and their cosmological principles.

The *Sphaera* of Sacrobosco was at the time, and up to the seventeenth century, still considered a valid source to teach and learn about the general structure of the

[188] On this treatise, see (Eagleton 2009). It is to be noted that, although the theory and the practice of dialing could be seen, according to the order of the parts of the *Protomathesis*, as the final aim of Fine's mathematical program, it is never described, contrary to astronomy, as the ultimate aim to study mathematics. In the *Protomathesis*, it appears rather as a domain of application of the knowledge presented in the *Cosmographia*, or as an extension of it, since Jim Bennett (Bennett 2012) showed that dialing, in this period and context, was also considered a means to gain cosmographical knowledge.

[189] This section is in large part derived from the analysis developed in (Axworthy 2016, 211–38). To avoid repetitions, I will not refer again to this prior study in this section.

cosmos in academic and non-academic circles (Crowther et al. 2015), even if the cosmological stances of the *Sphaera* were discussed and confronted with alternative theses in many of its commentaries, and this from an early time (Thorndike 1949; Oosterhoff 2015) (Chaps. 6 and 7).[190] Such discussions may be found, for instance, in the *Quaestiones* of Pierre d'Ailly (1350–1420) (Sacrobosco et al. 1498) and in the extensive commentary by Francesco Capuano de Manfredonia (Sacrobosco et al. 1499; Shank 2009) (Chap. 4).[191]

These discussions were not marked in the first decades of the sixteenth century by the strong debates raised in the late sixteenth and early seventeenth century on the cosmological models devised by Nicolaus Copernicus (1473–1543), Tycho Brahe (1546–1601), Johannes Kepler (1571–1630), and Giordano Bruno (1548–1600), but nevertheless acknowledged alternative models, such as those postulating the existence of homocentric planetary spheres, in place of the epicycles and eccentric spheres of Ptolemy.[192] In doing so, they contributed to opening the path to a progressive distancing from Sacrobosco's Ptolemaic universe, qualifying to a certain degree its value for the study of cosmology. This likely helped emphasize its importance for the more practical aspects of astronomy and for its applications to cartography, navigation, and judicial astrology, as shown by the great number of editions containing complementary technical information regarding such domains in the second half of the sixteenth century (Crowther et al. 2015; Oosterhoff 2015; Valleriani 2017). It nevertheless remained for certain later commentators, such as Christoph Clavius (1537–1612) and Francesco Giuntini (1523–1590), an appropriate place to discuss cosmological ideas (Sacrobosco and Clavius 1570; Sacrobosco and Giuntini 1577; Lattis 1994; Pantin 2013b).

Although Fine, through his editorial work on both Sacrobosco's *Sphaera* and on Peurbach's *Theorica planetarum* in the years 1515–1516 (Pantin 2010, 2012, 2013a), contributed to the diffusion of the Ptolemaic geocentric cosmological model, he also illustrated, through his subsequent astronomical publications, his awareness of the problems raised by the cosmological models promoted by Sacrobosco and by subsequent followers of Ptolemaic cosmology, such as Peurbach (Aiton 1987; Barker 2011; Malpangotto 2013, 2016), with respect to the principles of natural philosophy.

In 1521, Fine edited the *De motu octavae sphaerae* of Agostino Ricci (Ricci and Fine 1521),[193] in which an argumentation is presented against the existence of star-

[190] See, for example, the commentaries of Robert Anglicus, Michael Scot or Cecco d'Ascoli in (Thorndike 1949).

[191] Capuano also produced an often reprinted commentary on Peurbach's *Theorica planetarum* (Peurbach et al. 1495) and which Fine used for his 1515 edition of Peurbach (Pantin 2012).

[192] On the medieval and early Renaissance discussions on homocentric spheres, see (Duhem 1913–1959, II, 133–39, 146–56, III, 246–54; Carmody 1951; Kren 1968; Goldstein 1980; Grant 1994, 563–66; Lerner 1996, I, 99–110; Barker 1999, 2011; Shank 2002; Omodeo 2014, 77–79).

[193] Agostino Ricci was a converted Jew, a follower of Abraham Zacut, and a Christian kabbalist. He was for that matter the brother of Paolo Ricci, a professor of philosophy at the university of Pavia and later a physician at the court of Emperor Maximilian I, who translated the kabbalistic work

less spheres (such as the ninth sphere admitted by Sacrobosco) (Johnson 1946; Pantin 1995, 442; Nothaft 2017)[194] and which he followed in its broad outline in the *Cosmographia*, but also in the other astronomical works he published after 1521, at least through the visual representation of the cosmos he proposed in this context.[195] As indicated by Francis R. Johnson (Johnson 1946), the discourse of Ricci and Fine on this issue influenced Heinrich-Cornelius Agrippa (Agrippa 1531, F5v–F6r), a friend of Agostino Ricci,[196] but also Robert Recorde (ca. 1512–1558) (Recorde 1556, 10, 278–79) and Christopher Marlowe (1564–1593) (Marlowe 1604). Ricci and Fine's opinion was also referred to in a critical manner by Giuntini and Clavius in their respective commentaries on Sacrobosco's *Sphaera* (Sacrobosco and Clavius 1570, 68–69; Sacrobosco and Giuntini 1582, 17–19).

What Fine's *Cosmographia* provided in this respect in the continuation of Ricci's *De motu* was a reassessment of the cosmological model presented in the *Sphaera* and in later accounts of geocentric cosmology concerning the number of celestial

Sha'are Orah by Joseph Gikatilla under the title *De porta lucis* (Gikatilla and Ricci 1516). This translation was the main source of Johann Reuchlin's *De Arte Cabbalistica* (Reuchlin 1517). On Agostino and Paolo Ricci, see (Goodrick-Clarke 2008).

[194] As pointed out in the preface of this edition, Fine would have been incited to edit Ricci's *De motu* by members of the audience to the lectures he gave around 1520 on the motions of the eighth sphere. (Ricci and Fine 1521, 1v–2r): "Quemadmodum eruditissime Dionysi, ea quibus frequenter indigemus, si data investigentur opera, minus fiunt reperibilia: ita nonnunquam (licet insperata) et rebus et temporibus ultro se offerunt accommoda. Cum enim hisce diebus librum nostri Alberti Pighij doctissimi Mathematici, de aequinoctiorum et solstitiorum inventione, item de ratione celebrationis Christiani Paschatis, et ecclesiastici Kalendarij restauratione, quibusdam interpretarer: et accidentia singula quae ex illo accessus et recessus seu trepidationis imaginato motu, a junioribus octavae Sphaerae: peculiariter deputato, in talibus (si res ita se haberet) necessario subsequerentur, niterer ostendere: incidit forte fortuna in manus nostras (opportune tamen) libellus Augustini Ricij, viri in Astronomia non mediocriter eruditi, de ipsius octavae Sphaerae motu, opus et Mathematicis, et Philosophicis deductionibus ornatum. Quem quidem libellum cum nostris ostendassem auditoribus, et in eo pleraque tam de celestium mobilium numero, quam proprijs et indefessis, ipsorum agitationibus, nostris suasionibus quadrantia offendissent: orarunt statim (praecipue Nicolaus a Pratis, nostri amantissimus, et praeter reliquos de nobis bene meritus) ut eundem libellum ipsis, et omnibus Mathematicarum cultoribus, officio artis impressorie communicarem: quod faciliter exoravere."

[195] Fine's diagram of the eight-sphere model is presented in his *Theorique des ciels* (Fine 1528 and later editions), in all his editions of the *Cosmographia*, including the frontispiece of the *Protomathesis*, which was taken up in the unabridged 1542 edition (Fine 1542a); in the frontispiece of the commentary on the *Sphaera* by Lefèvre d'étaples (Sacrobosco and Lefèvre 1527), and in the *In eos quos de Mundi sphaera conscripsit* (Fine 1553b). It is also taken up in Charles de Bovelles's *Geometrie practique* (Bovelles 1551, 53r), for which Fine redrew the illustrations and which he contributed to editing, as well as insure it to be securely printed, as is indicated in the preface of the first edition (dating from 1542): (Bovelles 1551, 2r): "…Orontius Regius Mathematicus…. Duo protinus ingenuè spopondit. se quidem cum primis daturum operam, ut aereis tipis invulgata, plurimis esse visui: figurarum quoque quas ibidem frequentius inscripsi, futurum ligneis in tabellis pictorem. Necnon (quod praecipuum est) adversum mendas observaturum vigiles praeli excubias."

[196] (Agrippa 1531, F5v): "Augustinus Ritius, mihi in Italia summa familiaritate devinctus."

spheres.[197] In discussing the order of the cosmos in the first book of the *Cosmographia*, Fine did not aim to present the various opinions regarding the representation and division of the universe, as did certain previous commentators of Sacrobosco,[198] such as Pierre d'Ailly (Sacrobosco et al. 1498; Duhem 1916, 168–71), Prosdocimo de' Beldomandi (ca. 1380–1428) (Sacrobosco et al. 1531; Duhem 1913–1959, IV, 294–96; Markowski 1981), Francesco Capuano (Sacrobosco et al. 1508a; Shank 2009) (Chap. 4) in the fourteenth and fifteenth centuries, or Clavius at a later period (Sacrobosco and Clavius 1570), but rather to teach the version he judged to be physically true, as in the case of the mutual disposition of the spheres of water and earth, which he considered to form together a single orb instead of distinct concentric spheres, as was proposed in Sacrobosco's *Sphaera* in accordance with Aristotle's doctrine of the elements.[199] Yet on the issue of the number of celestial spheres, in addition to asserting his personal opinion, his intention was to offer a clear rebuttal of the theses he considered false.

It must be noted that Fine, in the *Cosmographia* as well as in the first pages of the *Theorique des cielz* (though in a much more concise version), was overall in line with the cosmological model transmitted by Sacrobosco, which is ultimately drawn

[197] An example of such discussions in later editions of Sacrobosco is provided by the case of Franco Burgersdijk's edition of the *Sphaera* (Burgersdijk 1626), considered by M. Buning in this volume (Chap. 11).

[198] For that matter, the first book of Sacrobosco, which is the second shortest chapter of the *Sphaera*, was often the object of the longest commentaries, given the controversial or problematic character of many of the questions raised by the topics it covered, such as the mutual disposition and relation of the spheres of the elements, particularly of earth and water, the number of celestial spheres, the possibility of contrary motions, as well as the centrality and immobility of the earth. The fourth book also offered the occasion to discuss the status of epicycles and eccentric orbs. See, for example, how Bartolomeo Vespucci, in his annotation to Capuano's commentary to Sacrobosco first published in 1508 (Sacrobosco et al. 1508a), presented the various topics with which dealt Sacrobosco in the *Sphaera*, in particular those of the first and last books (Sacrobosco et al. 1531, 2v): "De ordine namque coelorum, atque elementorum natura, situ, figura, motibus, et quantitate, maxima inter antiquos disceptatio fuit, Quidam totam etheream regionem unum et continuum, quidam plura et discontinua, hi octo ponunt sphaeras, illi novem, alii decem, quidam Solem immediate supra lunam in secundo loco statuerunt, quidam in quarto. Elementarem autem regionem alii ex uno, alii ex pluribus componi credebant quorum alii certum numerum statuerunt, quidam infinita dicebant, aliqui tam elementis quam ipsis corporibus coelestibus varias figuras tribuebant, diversitas autem opinantium arguit difficultatem in re, haec igitur omnia ac multa alia a nostro autore in primo capitulo brevissime declarantur. (In secundo vero), nomina ac definitiones circulorum sphaeram materialem integrantium, cui similem coelestem et illam imaginamur optime pertractat. Tertium vero diversum ortum et occasum signorum, dierum naturalium necnon artificialium varietates, ac terrae habitabilis in climata partitionem, res cognitu difficillimas nobis absolvit. (In ultimo) omnia fere quae in theoricis planetarum longo sermone pertractantur, compendiose perstringit. circa situm orbium, planetarum sphaeras integrantium, ac motum ipsorum, et de causis eclypsium, quae omnia apud antiquos maxime dubia fuerunt, cum aliqui eccentricos et epicyclos negaverint, alii concedentes plures aut pauciores posuerint, alii motum proprium sphaerarum ab occidente in orientem non crediderint, quae omnia aperte satis autor ipse quantum ad introductorium spectat nobis enodabit."

[199] (Fine 1532, I.6, 106r): "Estque ipsius Telluris et Aquae frustulatim circunsparsae unica continuave forinsecus superficies" and (106v): [*in marg.* Telluris et aquae superficies unica].

in its broad outline from Aristotle's *De caelo*, with the integration of Christian elements. Fine indeed defended in the first book of the *Cosmographia* the dual opposition between elementary and celestial regions, which compose together the whole universe, the elementary region representing the corruptible part of the universe and the celestial region, its incorruptible part.[200] He accepted the simplicity of the elements, as well as their quadripartition and mutual disposition within the sublunary region,[201] though he added to this (as was often done) their combination with the four sensible qualities (which Fine also represented as a diagram),[202] as well as the Aristotelian tripartition of the region of air (Heninger 1977b 32–33, 106–07; Cosgrove 2007).[203] He also took up Sacrobosco's argument of divine providence as an explanation for why the sphere of earth is not entirely covered by the sphere of water, judging insufficient the physical arguments traditionally brought forth, such as the absorbent power of earth or the influence of the stars.[204] He admitted, more-

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[200] (Fine 1532, I.1, 102v): "Mundum igitur appellamus, perfectam et absolutam omnium congeriem, vel ornamentum: unde a graecis *κόσμος* dicitur. Divinum certe, et admirandum naturae naturantis opus: finitum tamne, licet infinito simile videatur. Cuius partes principaliores duae, et sensu, et ratione convincuntur: coelestis, et elementaris…sunt elementa, generationibus et corruptionibus continuo vacantia…. Coelestem porro machinam, nihil aliud, quam ipsum ingens coelum vocare solemus, omni prorsus alteratione privatum…." See also (Fine 1528, 2r): "tout le monde est universellement composé de deux principales parties, c'est à sçavoir de la region celeste, et de la region elementaire."

[201] (Fine 1532, I.2, 102v): "Elementaris regio quatuor simplicibus elementis, Igne, Aere, Aqua, Terra, et diversa ex eorundem commixtione generatorum specie resultat. Inter haec autem quatuor elementa, Ignis omnium supremum, Aerem trifariam divisum circulariter ambit, Aer Aquam, Aqua verò Terram." See also (Fine 1528, 2r–v): "Par la region elementaire nous entendons les quatre simples elemens: qui sont le Feu, l'Air, l'Eau, et la Terre: et avec ce tous les corps parfaicts ou imparfaicts, vivans ou non vivans, faicts et composez materiellement ou virtuellement, par l'alteration, corruption, mixtion, union, et vertu desdicts quatre elemens…. La terre est au mylieu de tout le monde, comme centre universel d'iceluy. Environ et par dehors ladicte terres est l'Eau…. L'air environne et circuit rondement ladicte superfice exterieure de l'Eau et de la Terre descouverte…. Le feu finablement environne rondement l'Air, tellement que lesdictz quatre elemens tendent naturellement a rotundité, et font une sphere…" It may be noted that the elements, though maintaining the same disposition, are presented in the *Cosmographia* in the reversed order.

[202] (Fine 1532, I.2, 103r): "Secundo, quoniam per Philosophum (secundo de generatione) tot sunt elementa, quot primarum qualitatum combinationes possibiles. sed quatuor tantummodo reperiuntur: utpote, caliditatis et siccitatis, quae Ignis propria est: caliditatis et humiditatis quae naturalis Aeri: frigiditatis et humiditatis competens Aquae: frigiditatis et siccitatis ipsi Terrae peculiaris." See also (Aristotle, *On Generation and Corruption* 330a30–330b6; *Meteorologica* IV.1378b10–25 and *sq*).

[203] (Fine 1532, I.2, 103r): [*in marg.* Aeris cur tres regiones.]. See also (Fine 1528, 2v): "Lequel air es accidentalement distingué en trois interstices, regions principales…." See also (Aristotle, *Meteorologica* I.3, 340b).

[204] (Fine 1532, I.2, 103v): "De ratione tandem partium ipsius Terrae discoopertatum, nullum sufficiens argumentum, nec ex astrorum attractiva virtute, nec ex Telluris siccitate quae Aquam sorbeat, elici posse videtur: sed solius divinae bonitatis providentia, quae sic Aquas congregavit, et Aridam, hoc est, Terram apervit, ut creatura rationalis ad sui similitudinem et imaginem facta, super eam vivere posset, et cunctis Terrae Marisque frueretur nascentibus." See also (Fine 1528, 2v): "La terre est au mylieu de tout le monde, comme centre universel d'iceluy. Environ et par dehors ladicte

over, that the heavens are made of ether,[205] as well as their essential incorruptibility and circular motion around the earth.[206] He also accepted the sphericity and finiteness of the universe, taking up two of the three arguments given by Sacrobosco to prove that the sky is spherical—namely, the arguments of commodity and of necessity, leaving aside the theological argument of the similitude between the universe and the divine archetype or creator.[207] Although he mentioned the argument Sacrobosco drew from al-Farghānī in favor of the sphericity of the heavens (according to which the sun would be closer when situated above us and further away when situated nearer to the horizon if the heavens were not spherical), he did not mention the theory of the refraction caused by the vapors of the atmosphere to explain why the sun actually seems closer to us near the horizon, perhaps because he was aware of the falseness of this theory (Pantin 2001).[208]

He also accepted the division of the heavenly realm into concentric contiguous spheres[209] according to the different motions that take place in it, as well as the

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terre est l'Eau, redigee en moindre quantité, et plus contraincte que sa naturelle disposition ne requiert: et ce pour la decouverture des parties exterieures de la terre, necessaires à l'habitation et vie des vivans: tellement que l'Eau et lesdictes parties descouvertes de la Terre, font une mesme superfice par dehors: tendant par tout endroit comme un mesme corps a rotundité."

205 (Fine 1532, I.3, 103v): "Ex supradictis relictum est, coelum ab elementis in hoc differre, quod omni corruptiva privetur alteratione, id est, uno et semper eodem modo se habeat, lumen tantummodo perfective suscipiendo: unde quinta a philosophis essentia, hoc est, alterius et perfectioris a quatuor elementis essentiae mervit appellari." See also (Fine 1528, 2v–3r): "autour et environ et environ la region ou sphere elementaire, est la celeste region, environnant et circundant orbiculairement et rondement lesdits quatre elemens, claire, luisante, et decoree de plusieurs estoilles et de plus parfaicte nature que les dessusdits elemens, dont on la nomme la quintessence."

206 (Fine 1532, I.4, 105r): "Adde, quod nobiliori corpori perfectior debetur motus, qualis est circularis. Fit namque circa medium, cui sola orbium coelestium sphaerica figura convenire videtur, foreque aptissima. Motus enim qui a medio, vel ad medium Universi contingunt, ipsis quatuor elementis solummodo competere supra monstravimus. Motus igitur circularis ipsius coeli proprius esse videtur: sunt enim tot simplicia corpora, quot simplicium motuum occurunt differentiae, et econtra." See also (Fine 1528, 2v–3r) and previous note.

207 (Fine 1532, I.4, 104v): [*in marg.* Quod coelum sit sphaericum Prima ratio, à commoditate. Secunda ratio à necessitate]. The fact of leaving aside the similitude argument presented in Sacrobosco to prove the sphericity of the heavens is in line with Fine's will to mainly provide demonstrations that depend on rational arguments (mathematical or physical). When he favors the theological argument over other types of arguments to explain the partial emergence of the earth above the oceans, it is because, as he clearly says, he judged insufficient the physical arguments set forth by his predecessors.

208 (Fine 1532, I.4, 104v–05r): "Praeterea, quemadmodum dicit Alphraganus, si coelum esset angularis, vel irregularis figurae, cum Sol universum coeli ambitum semel in anno circumgyret, aliquibus anni temporibus solito major notabiliter appareret, alijs vero minor: propter necessariam laterum vicinitatem, et angulorum remotionem."

209 (Fine 1532, I.3, 103v): "Coelestis porrò machina quinta à philosophis essentia nuncupata, in octo principales orbes, utraque terminativa superficie Mundo concentricos, et sibi invicem contiguos disgregatur: utpote, septem errantium syderum vel planetarum orbes, et Firmamentum omnium maximum." See also (Fine 1528, 3r): "Et tout ainsi que la region elementaire est divisee en plusieurs parties, aussi la celeste machine est separee realement en plusieurs ciels, et orbes particuliers:

double motion of the heavens, from east to west (for the daily motion of the entire universe) and from west to east (for the particular spheres of the planets and of the firmament).[210] He also accepted the order of the planets taken up by Sacrobosco from Ptolemy, despite the uncertainties and debates relating to the order of the sun, Mercury, and Venus (given the quasi-equality of their period of revolution), just adding to this the numbers given by Ptolemy and al-Battānī for the revolution of the fixed stars.[211] In this context, he included a table to display the physical qualities of the planets.[212]

If Fine assumed that the sphere of earth and the sphere of water together form a unified globe, he admitted, through arguments found in Sacrobosco's *Sphaera*, that the resulting globe is situated at the center of the universe,[213] is deprived of motion,[214]

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c'est à sçavoir en sept orbes deputez aux sept planetes, et le firmament dit la huitieme sphere, où sont les estoilles fixes. Et faut imaginer que ces huit orbes sont uniformes, c'est à dire d'une egale crassitude, contigus l'un à l'autre, et concentriques, c'est à dire ayans un mesme centre avec le monde universel."

210 (Fine 1532, I.5, 105r–v): "Universa nanque Coeli machina, circa Terram, veluti propria et indefessa Mundi latione, ab oriente per meridiem ad occasum, regulariter circunducitur: completam revolutionem intra 24 horarum intervallum adimplendo. Singuli tamen orbes in diversis temporum spatijs, motu proprio, ab occidente ad ortum contra nituntur." See also (Fine 1528, 3r): "les ciels dessusdicts ont deux principaux mouvemens: dont l'un est commun a tous les ciels, et l'element du Feu, et la plus haute region de l'Air, tournant avec lesdicts ciels comme si ledit mouvement estoit universel, propre, et commun a tout le monde. Lequel mouvement faict sa revolution en vingt quatre heures egales, d'orient en occident, sur les deux poles du Monde, au long de l'equinoctial…. Le second mouvement, est le mouvement particulier du firmament, et des sept Planetes, qui est divers, et irregulier quant au centre du monde, et fait sa revolution en diverses espaces de temps, selon la diversité des orbes, d'Occident en Orient, au contraire du premier, sur les poles du zodiac au long et selon l'ordre des douze signes."

211 (Fine 1532, I.5, 105v–06r): "stellatus enim orbis in 36,000 annis secundum Ptolemaeum, vel in 23,760 juxta mentem Albategni circulum complet, Saturnus verò in 30 annis, Juppiter in 12, Mars in duobus, Sol in 365 diebus et ¼ ferè (quae annum faciunt), Venus atque Mercurius veluti ferè Sol, Luna autem in 27 diebus et 8 circiter horis, integram circunductionem absolvit." See also (Fine 1528, 3r): "l'ordre [des huit ciels et orbes particuliers] est trouvé estre tel comme s'ensuit. Le Ciel de la Lune est prochainement environnant l'element du Feu. Au dessus du Ciel de la Lune, est celuy de Mercure. Puis le ciel de Venus, au dessus duquel est le ciel du Soleil. Puis celuy de Mars, apres lequel est le ciel de Jupiter, et finablement le ciel de Saturne, au dessus duquel est le Firmament, le plus grand de tous." As with the enumeration of the elementary spheres, the celestial spheres are presented in the *Cosmographia* in the reversed order.

212 (Fine 1532, 104r–v): "ordo planetarum, deinde characteres, postea colores et eisdem signis attributae naturae, sigillatim annotatur."

213 (Fine 1532, I.6, 106v): "Dico praeterea, quod Terra medium Universi possidet. Nam per ea quae dicta sunt, Terra, velut omnium gravissima, deorsum moveri semper est inclinata: quousque sub caeteris elementis locum possideat infimum, sed omnium locorum abjectissimus est medium Universi, hoc est, Mundi centrum: quicquid enim ab eo recedit, necessum est ascendere, quod ipsi Terrae negatum esse videtur." See also (Fine 1528, 2v): "La terre est au mylieu de tout le monde, comme centre universel d'iceluy."

214 (Fine 1532, I.6, 106r): "Terra verò motum localem non habet, sed medium Universi possidet immobiliter."

possesses a spherical form,[215] and is of imperceptible magnitude in comparison to the universe, being therefore assimilable to a geometrical point.[216]

As indicated above, the two chapters in which Fine deviated the most from the cosmological model transmitted by Sacrobosco and by later geocentric cosmological accounts are chapters 3 and 5 of Book I, where he respectively dealt with the number of celestial spheres[217] and with the mode of transmission of the diurnal motion (and of motion in general) from the *primum mobile* (or the first moved sphere) to the inferior spheres.[218]

In these two chapters, Fine rejected the systems that admit the existence of one or several mobile spheres deprived of stars above the sphere of the fixed stars on account of their incompatibility with the principles of natural philosophy established by Aristotle (Johnson 1946; Heninger 1977b, 38–39; Pantin 1995, 442; Cosgrove 2007; Nothaft 2017). Such cosmological models, which were by far the most popular in the Middle Ages and in the Renaissance, included therefore not only the representation of the cosmos adopted by Sacrobosco, which postulated the existence of nine concentric contiguous orbs or spheres (with one starless sphere above the Firmament as the *primum mobile*), but also the models that admitted ten spheres, as illustrated, for example, by the representation of the universe provided in Apian's *Liber cosmographicus* (Chap. 5) (with two starless spheres above the fixed stars).[219] Fine took up this discourse in the unabridged version of the second edition of the *Cosmographia* dating from 1542 in a shorter and slightly modified version (Fine 1542a, 3r, 5r), but not in the abridged version, nor in the later editions. However, he maintained in all these versions the diagram representing the heavens as composed of only eight spheres.

The number of distinct celestial spheres or heavens was an important issue in the development of premodern cosmology, especially in the context of treatises on the *Sphaera*, since the attribution of a distinct encompassing sphere for each distinct celestial motion stemmed from the will to account for the appearances while offering a cosmological model that conformed to the principles of natural philosophy. In this sense, it held a comparable status to the problem of the reality of Ptolemy's epicycles and eccentric circles in the tradition of the *Theorica planetarum*, although

215 (Fine 1532, I.6, 107r): "Hanc porro Telluris et Aquae superficiem, rotundam ex omni parte habere figuram, hoc est, quovis modo Terra vel Aqua extrinsecus consyderetur, in rotunditatem undiquaque conglobari, talibus argumentis, seu rationibus persuaderi compellimur." See also (Fine 1528, 2v): "l'Eau et lesdictes parties descouvertes de la Terre, font une mesme superfice par dehors: tendant par tout endroit comme un mesme corps a rotundité."

216 (Fine 1532, I.6, 106r): "In hunc quippe modum, ut compositus ex Terra et eadem Aqua globus, respectu totius Universi, insensibilis censeatur esse quantitatis, et veluti punctum, centrum ejusdem Universi repraesentare videatur."

217 (Fine 1532, I.3, 103v–04v): *De coelestium orbium numero, atque positione*.

218 (Fine 1532, I.5, 105v–06r): *De generali eorundem coelestium motuum expressione.*

219 See Apian's illustration of the various spheres that compose the celestial region (Apian 1533, 4r). A system of ten spheres was also adopted by Conrad Tockler (Chap. 5), as well as by André do Avelar (Chap. 10), among others.

it did not raise as many difficulties as the latter.[220] As will be shown later, Fine addressed both issues, although he mainly focused on starless spheres.

In this framework, the necessity to postulate the existence of one or several spheres above the Firmament, which was initially held to surmount the seven spheres of the planets and to enclose the whole universe, was due to the fact that the fixed stars (according to the observations of astronomers since Hipparchus (ca. 190–ca. 120 BCE)) were seen to move according to two distinct motions taking place in opposite directions and that (according to Aristotelian physics) it would be impossible for one single material body, especially a body made of pure and immutable matter, to properly move according to two distinct and opposite motions. In other words, as the sphere of the fixed stars was at first attributed the diurnal motion—that is, the east-to-west motion of the entire universe in twenty-four hours, since it is the most exterior of all celestial spheres and thus the only sphere able to carry the whole universe in its motion at once—it could not also be properly and simultaneously attributed the motion of precession of the equinoxes, according to which the fixed stars appeared to move of approximately one degree from west to east every century on the poles of the ecliptic, completing their revolution in thirty-six thousand years (according to Ptolemy, on the basis of Hipparchus's discovery) (Neugebauer 1975, 54, 160, 292–97). For this reason, astronomers and natural philosophers admitted the existence of a sphere deprived of stars above the Firmament, which would be the proper cause of the diurnal motion of the universe. The eastward motion of precession of the equinoxes could therefore be properly attributed to the sphere of the fixed stars, as in the cosmological model depicted by Sacrobosco.

The later admission of a tenth sphere, and hence of an additional starless sphere above the Firmament, was based on the observation of a motion distinct from the diurnal motion and from the precession of the equinoxes in the trajectory of the fixed stars. Indeed, while the fixed stars were already seen to revolve (along with the planets) from east to west in twenty-four hours, and from west to east uniformly by one degree every century according to the precession of the equinoxes, the equinoxes (the first degrees of Aries and of Libra) were also observed to move back and forth in small circles over a period of seven thousand years, resulting in a complete revolution of the eighth sphere in forty-nine thousand years. This motion of oscillation of the equinoxes, which is described in a work entitled *De motu octavae sphaerae* and regarded as a Latin translation of a treatise by the Arab mathematician Thâbit ibn Qurra (Thâbit ibn Qurra 1960; Neugebauer and Thâbit ibn Qurra 1962), was commonly called by the Latin astronomers trepidation (*trepidatio*), or motion of access and recess (*accessus et recessus*) (Neugebauer 1975, 298, 598, 631–34; Nothaft 2017). While trepidation was initially admitted as a correction of the motion of precession of the equinoxes, it came to be considered in the Latin world as a motion independent of the latter, requiring it to be accounted for by a separate sphere, distinct from the ninth, to which the precession of the equinoxes had been

[220] On the difficulties raised over the possibility of epicycles and eccentric circles in the medieval and Renaissance Latin tradition, see, for instance, (Kren 1968; Goldstein 1980; Hugonnard-Roche 1992; Grant 1994, 278–88, 303–08; Lerner 1996, 111–14; Barker 2011) (Chap. 6).

previously attributed (Dobrzycki 2010 [1965]; Neugebauer 1975, 633; Grant 1994, 315–16; Nothaft 2017).[221]

Although the addition of a ninth and a tenth sphere, just as the admission of partial orbs, stemmed from the will on the part of astronomers to account for the apparent motions of the stars through a system that would conform to the principles of Aristotelian natural philosophy (Morelon 1999) (at least to some of them),[222] certain reservations were raised with regards to the ontological status of these spheres, as the fact that they did not carry any star made it difficult to prove their physical reality, just as it was to prove the existence of epicycles and of the eccentric spheres.[223] One of Sacrobosco's early commentators, Robert Anglicus, objected to the existence of a ninth sphere in so far as it contradicted the principle that nature does not do anything in vain, since (as established by Aristotle) the orb only exists in order to carry a star (Thorndike 1949, 147). In line with this objection, some philosophers and astronomers added that if these were only fictional devices aimed to account for the apparent motions of the fixed stars, as did Averroës, Nicole Oresme (ca. 1320–1382), as well as Agostino Ricci they should be banished from the astronomical representation of the cosmos, given that there are other, more simple ways to account for the motion of the fixed stars (Ricci and Fine 1521; Oresme 1968, 488–91; Grant 1994, 319; Lerner 1996, I, 201–08).

The arguments Fine set forth in his *Cosmographia* against the existence of starless spheres (and therefore against the systems postulating more than eight celestial spheres) are founded on Aristotelian physical principles, but also on the assertion of its incompatibility with judicial astrology.[224] Following Agostino Ricci's *De motu octavae sphaerae* (Ricci and Fine 1521), Fine intended to show in chapter I.3 that neither the principle established by Aristotle that one simple body cannot be properly attributed two different motions[225] (and which is a key-argument for dividing the heavens into different ethereal spheres),[226] nor the visible motions of the stars,

[221] On the reception of the theory of trepidation in Renaissance France, see (Pantin 1995, 435–56).

[222] In these cases, mainly the circularity of celestial motions and the attribution of a particular sphere for each motion.

[223] On the debates concerning the ontological status of eccentric spheres and epicycles prior to Fine, see (Chaps. 5 and 6).

[224] As shown by Pantin (Pantin 1995, 436–37, 440), the attribution of supplementary motions to the eighth sphere, and thus of additional spheres above it, was detrimental also to the computation of calendars, as it required one to accurately determine the duration of the solar year, as well as to calculate the motions of planets, whose positions were determined in reference to the positions of the zodiacal signs.

[225] (Aristotle, *De caelo* I.2, 269a2–9, II.8, 289b31–32; *Metaphysics* V.6, 1016a5–6).

[226] (Fine 1532 (*Cosmographia*, I.3), 103v): "Saniores tamen in hoc convenerunt, quod septem sunt orbes planetarum, id est, errantium syderum, utpote Saturni, Jovis, Martis, Solis, Veneris, Mercurij, et Lunae: una cum orbe stellarum fixarum, hoc est, fixam et invariatam inter sese distantiam observantium, quod Firmamentum a fixione syderum appellare solemus. Perceptum est etenim, septem errantia sydera varijs et inaequalibus circunduci motibus, a peculiari stellarum fixarum latione

compel us to believe that there are more than eight celestial spheres in the heavens.[227] The only additional sphere he was willing to place above the sphere of the fixed stars is the Empyrean heaven, which had been admitted by his predecessors for theological reasons, as the abode of divine and holy beings.[228] The Empyrean heaven would probably have been admissible for Fine because it was generally understood as deprived of motion, and therefore would not have compelled him to postulate any other motion than those attributable to the stars and to the whole universe.[229]

Appealing to the authority of Plato (ca. 427–347 BCE), of Aristotle, of Ptolemy, and of Averroës—followed, he claimed, by most mathematicians[230]—Fine described the celestial models which admit more than eight material spheres as dreams or fictions, saying (through a discourse that is very close to Ricci's words) that "those who, against so many renowned authors, have imagined (for some of them) nine and (for most of them) ten spheres, violated, without being forced to it by any compelling reason, the number of solid celestial orbs."[231] Moreover, Fine said (again paraphrasing Ricci) that the more recent astronomers who defended the ten-sphere

distinctis. At cum stellae non moveantur nisi ad motum orbis (secundo Coeli) necessum est ipsum coelum in tot orbes particulares separari, quot sunt diversi motus astrorum simplices. Si nanque coelum esset continuum, unico simplici motu circunvoleretur (quinto Metaphysicae) quoniam impossibile est idem corpus simplex pluribus moveri simplicibus motibus (primo Coeli)."

[227] (Fine 1532, 103v): "Octo igitur praecipui sunt ponendi coelestes orbes: praedictorum videlicet septem planetarum, et Firmamentum omnium aliorum maximum, tot, tamque decoris syderibus ornatum. Supra quem fixarum stellarum orbem, nec syderum claritate, nec aliqua convincente ratione, coelum aliquod mobile cogimur assignare."

[228] On the function and the status of the Empyrean heaven in medieval theology and cosmology, see (Grant 1994, 371–89; Bezza 2014).

[229] (Fine 1532, 103v): "Admittimus tamen (si universa coelorum non sufficiat machina) coelum empyreum nominatum, felicem beatorum sedem, ne videamur a Theologorum opinione dissentire: id tamen ab omnibus, etiam philosophis, quiescere dicitur."

[230] (Fine 1532, I.3, 103v–04r): "Octonario igitur, cum veteribus, et quidem probatissimis Caldeorum, Aegyptiorum, et Graecorum (qui circa motus astrorum philosophati sunt) erimus contenti mobilium coelorum numero. Nec plures divinus ille Plato in de Repub. Epinomides, et de Thimaeo, Aristoteles secundo Coeli, et ejus Commentator Averrois, et Ptolemaeus primo et septimo magnae constructionis possuisse videntur: imo nec universa mathematicorum schola, paucis admodum exceptis." On this issue, it is interesting to note that the historical studies written on this topic from the nineteenth century show, on the contrary, that most precopernican astronomers postulated the existence of at least nine spheres, if not ten, to account for the anomalies which were observed in the motion of the fixed stars (Duhem 1913–1959, II, 204; Grant 1994, 315–18; Lerner 1996, 205).

[231] (Fine 1532, I.3, 103v–04r): "quorum aliqui novem, plaeriquae decem, contra tot gravissimos authores imaginati sunt, et stabilium coelestium orbium numerum, nulla cogente ratione, violarunt." See also (Ricci and Fine 1521, 19r): "Stultum igitur per Herculem, atque temerarium esset, contra tot gravissimos tum philosophiae tum mathematicae authores novam sententiam proferre: Et statutum jam per tot temporum curricula coelorum numerum, nulla cogente ratione violare."

system "wrongly attributed such an extravagance to Ptolemy, to King Alfonso and to Johannes Regiomontanus."[232]

As Ricci had done when he invoked the authority of Averroës in order to disprove the existence of starless spheres, Fine first appealed to the physical principle of simplicity or economy, stating that, in nature, a system that is simpler or that appeals to a smaller number of causes will always be chosen over a system that is more complex and that admits a greater number of causes than required.[233] In this context, the precession of the equinoxes would be accounted for through the distinction between the motion of the part and the motion of the whole.[234] By admitting that the precession of the equinoxes properly belongs to the eighth sphere, Fine supposed that the diurnal motion may be assigned to the latter only in so far as it partakes, just as any other celestial spheres, in the motion proper to the whole universe.

To explain how the universal motion can be transmitted to all the celestial spheres without having to be properly attributed to the last or highest sphere (as this sphere would otherwise need to transfer the diurnal motion to the inferior spheres by dragging the sphere immediately inferior and contiguous to it in its motion, which would then transmit it to the sphere immediately inferior to it, and so on), Fine adopted the causal model defended by Ricci, and before him by Averroës in his commentary on Aristotle's *De caelo*, according to which the sphere of the fixed stars would move the whole world and each of its parts by transmitting to the inferior spheres the vital virtue necessary for them to start moving spontaneously, according to their individual trajectory.[235] To defend this thesis, Fine appealed (as did Ricci) to the traditional

[232] (Fine 1532, I.3, 103v–04r): "Cujus quidem opinionis extremae, utpote, quae denarium admittit, imo verius somniat orbium coelestium numerum, sunt omnes fere juniores: qui tantae dementiae Ptolemaeum, Alphonsum regem, et Joannem Regiomontanum authores esse mentiuntur." See also (Ricci and Fine 1521, 7r): "Sexta adhuc juniorum hodie late diffusa patet opinio, universis fere hac tempestate astronomizantibus praeter caeteras probata. Cujus autorem Alphonsum regem Castellae esse mentiuntur, atque Joan. de Regio monte." For an account of trepidation and of its reception in the medieval tradition of the Alfonsine tables, see (Dobrzycki 2010 [1965]; Nothaft 2017).

[233] (Fine 1532, I.3, 103v–04r): "Quemadmodum in secundo nostrae Mathesis volumine, ubi particulares coelestium orbium motus tractabimus, suo loco monstrare nitemur: ubi non licere videbis (nisi prorsus orbatis philosophia) nova entia fingere, et multiplici id instrumento salvare, quod unico naturaliter et evidenter permissum est." See also (Ricci and Fine 1521, 19r): "Neminem enim, nisi forte philosophia orbatum, latere potest quantum sit a recte philosophantibus alienum, nova fingere entia: quod enim unico instrumento natura fieri licet, non construitur duplici, teste Aver. 12. Meta., et eo magis quo circa nobiliora versatus entia fueris." See also (Averroës 1562, lib. XII, co. 45, 329G): "Quòd autem sint duo motus à duobus corporibus, non indigetur. quod enim potest natura facere uno instrumento, non facit duobus."

[234] (Fine 1532, I.5, 106r): "Coelorum motus in duplici reperiri differentia, proxime descripsimus: reliquum est, hic declarare, undenam proveniat regularissimus ille ab ortu ad occidentem, et eidem adversus ab occidente ad ortum syderum motus. Primus itaque motus (ut re acu tangamus) totius Universi proprius esse videtur: nec quispiam orbium particularium hoc motu proprie vel seipso circunfertur, sed tantummodo veluti pars ipsius Universi." See also (Aristotle, *Physics* VI.10, 240b9–17).

[235] (Fine 1532, I.5, 106r): "Virtus itaque motiva hujus primi atque regularissimi motus, per universa diffunditur corpora: quae alio, quam hoc primo motu, propria et intrinseca latione circunferri (super alijs tamen polis et axe) nullum sequitur inconveniens, cum alius sit motus totius (sexto Physicorum) alius vero partis." See also (Averroës 1520, II, com. 42, 121v–22r, com. 71, 141r–v).

comparison between the macrocosm (the universe) and the microcosm (the human being or the living being) to show that the whole body of the universe, just as the body of man or of the animal, can be said to move according to one motion, while its inner parts (the spheres, or the limbs of the living body) move according to distinct motions.[236] These would nevertheless also be moved with the whole body according to its proper motion. In this framework, since the whole universe, rather than a separate sphere, is said to properly move from east to west, the eighth sphere may be considered as properly moved according to the precession of the equinoxes.

Within such a system, the attribution of the diurnal motion to the whole aggregation of the spheres, and not to one particular sphere, certainly renders obsolete the mechanical model commonly presented during the Middle Ages, notably in Sacrobosco's *Sphaera*, to account for the transmission of the diurnal motion to the totality of the particular spheres—that is, through the *raptus* exerted by the higher sphere on the sphere immediately inferior to it and thereby on the rest of the spheres successively (Lerner 1996, 179–80, 188, 195–201; Grant 1997). Nevertheless, the concept of a first moved sphere, or *primum mobile*, to which the diurnal motion is properly attributed and which would transmit to the other spheres the power to move according to its own motion,[237] is not entirely done away with, since this model still requires a sphere that receives the vital virtue of the whole universe in the first place and transmits it to the other spheres (including the spheres of

[236] (Fine 1532, I.5, 106r): "Exemplum habemus de microcosmo, id est, homine: eo nanque deambulante, et velut seipso constat agitato, non repugnat manum, vel aliud quodvis membrum particulare interea moveri. Cum igitur adgregati coelestes orbes unum corpus juxta Philosophos constituant, et veluti particularia membra ipsum animal (est enim coelum animatum) spirituali ligamento videantur integrare: erit totius coeli motus unus, velut animalis, utpote, is quem ab ortu ad occasum in 24 vulgarium horarum intervallo, suam circunductionem regulariter adimplere dietim experimur. Unde cum vulgares metiantur dies, ac per eundem motum vulgus ipsum reguletur, motus hic diurnus et mundanus ab omnibus appellatur." See also (Ricci and Fine 1521, 9v–10r): "…necessario esse coelum unum numero, quod ex pluribus corporibus, quasi ex membris animal constat: est enim coelum animatum, ubi supra, igitur et unum animal erit…licet tamen isthaec animae coeli ejusque corporis unio, non sit quales perhibentur esse, quae inferiorum sunt copulae animarum, atque corporum. Est itaque diurnus motus totius coeli proprius, nec est partialum sphaerarum quaepiam quae seipsa hoc motu et proprie, sed solum veluti pars totius cietur. Nihil autem inconveniens esse videtur partialia corpora alio, quam totius, motu deferri, uti ait Commentator praeallegato loco, sicuti et manus currentis hominis eam interea ad alteram continuo partem moventis: haec enim manus absque dubio duplici latione agitabitur, altera scilicet tanquam pars totius, altera vero tanquam quippiam seipso constans: diversos enim esse motus secundum quod totius, et secundum quod partium ex sexto physicorum docemur." See also (Averroës 1562, 387K–L).

[237] (Fine 1532, I.5, 106r): "Octavus tamen orbis, hoc est, Firmamentum, primum mobile (si velis) nominari poterit, non quod suo motu caeteros rapiat orbes: sed veluti principale membrum, eam motricem vim primitus accipiat, quam postmodum ad caetera videtur emittere coelestia corpora. Quemadmodum cor humanum, a quo virtus vitalis reliquis membris dispensatur, quam primum accipit, unam tamen velut pars cum toto corpore fertur: quasi motiva vis sit in toto corpore, et a corde principaliter diffundatur."

the elements).[238] The *primum mobile*, just as the heart, Fine says, is the first organ to receive the vital virtue of the living body, through which it will be transmitted to the remaining limbs or organs. Here, the *primum mobile* would still correspond to the highest sphere, because it is the most perfect sphere, being endowed with the most uniform motion and being the closest to the Empyrean heaven and to God (Ricci and Fine 1521, 10v; Grant 1994, 322–23; Lerner 1996, 204–05).[239] Hence, Fine declares that it is "absurd and directly alien to philosophy, against nature and the order of things, to imagine new heavens on the Firmament and to dream of superfluous mobile circles without being compelled to it by reason or persuaded by experience."[240]

In the cosmological model then depicted by Fine, no place is left for the trepidation or the oscillation of the equinoxes observed in the trajectory of the fixed stars, which Fine, like Ricci, simply rejected as physically impossible. As he presented the modern determination of the motions of the eighth sphere,[241] he declared, explicitly

238 (Fine 1532, I.5, 106r): "Praeterea, elementum Ignis, una cum supremo Aeris intersticio, hoc quem diximus ab oriente ad occidentem, motu, regulari circunductione rotatur, quod indicant cometae, in eadem suprema Aeris regione plaerunque generati. Ex quo rursum liquet, ipsum motum diurnum non modo coelestibus orbibus, verumetiam elementis esse communem, id est universae Mundi structurae peculiarem."

239 See also (Ricci and Fine 1521, 10v). For Ricci, who follows Averroës on this point, if the eighth sphere can be considered the source of the motion of the other spheres, it is because it is the noblest and thus the first to associate itself with the motion of the whole universe. In this framework, the proper cause of the motion of the universe is its desire to imitate and to assimilate itself, by the uniformity and eternity of its motion, to the divine mover. On the notion of *primum mobile* and its status in premodern astronomy, see (Granada 2004).

240 (Fine 1532, I.5, 106r): "Quam absurdum igitur, et a recte philosophantibus alienum sit, contra naturam, atque rerum ordinem, nulla cogente ratione, vel experimento persuadente, novos supra Firmamentum effingere coelos, et superflua somnia mobilia, pluribus hic dissererem nisi me latius de his alibi (Deo duce) pertractaturum sperarem." As put forth by Pantin (Pantin 1995, 441–42), this judgment was also held by Albert Pigghe concerning the ninth and tenth sphere in the *De aequinoctiorum solstitiorumque inventione*; (Pigghe 1520, 20r–v): "Sed nec ego coelum ullum supra firmamentum aut orbem octavum esse crediderim (de beatorum sede hic nullus sermo est) quoniam nemo quantumvis linceus supra firmamentum aliquid videre potuit, nec aliqua adhuc ratio est inventa, quae mihi id persuadere possit….Non sum tam supersticiosus Astronomus ut omnia ita se in coelo habere putem quaecunque ingeniose excogitaverunt Astronomi ad apparentias coelestium motuum salvandas…. Alioqui, etsi omnino credere libeat cuncta ita esse disposita in coelesti illa millitia, qualia ab astronomis nostris comenta sunt et excogitata, sintque vere duo illi motus diversi in octava sphaera, videlicet motus accessus et motus augium et stellarum fixarum, quorum unicuique proprium mobile assignari opporteat, non tamen effingam nonam sphaeram…. Esse itaque supra firmamentum seu octavam spheram aut decimum, aut nonum coelum, nec sensus percipit, nec ratio docet." Fine states, in the preface of his edition of Ricci's *De motu*, that it is while teaching Pigghe's *De aequinoctiorum solstitiorumque inventione* that he introduced his audience to Ricci's *De motu*. On Fine's relation to Pigghe, see (Dupèbe 1999, 528–29; Pantin 2009b); and on Pigghe's approach to astronomy and astrology, see (Vanden Broecke 2003, 85–91).

241 (Fine 1532, I.5, 106r): "Juniorum tamen quorundam, imo fere omnium, esse videtur, ut stellatus orbis duplici motu, praeter diurnum (quem ficto tribuunt mobili) circunferatur. Primo, ab occidente ad ortum, in quibuslibet 200 annis uno fere gradu: quem motum a somniata nona sphaera pendere

referring to Ricci's *De motu* (and agreeing with him on the rate of precession, following al-Battānī),[242] that trepidation should not only be rejected because it contradicts the physical principle of uniformity of celestial motions, which (given the difformity of such a motion) cannot be rationally seen as going back and forth, but also because its admission would overthrow judicial astrology—that is, would call into question the validity of the astrological art and the predictions of its practitioners.[243]

> We do not want to 'titubate' (*titubare*)[244] any longer on this inconceivable motion (as when we follow the opinion of other astronomers), since we declare and openly acknowledge, driven by reason, that this opinion is the weakest, not to say the falsest of all, and was fallaciously imagined by the most pernicious and most ignorant disciples [of astronomy], causing the greatest damage to human beings by overthrowing judicial astronomy. For I know that there is nobody (who is not entirely deprived of philosophical knowledge) who denies that this highly irregular motion of celestial bodies is repugnant to all, as Agostino Ricci demonstrates in his small treatise.[245]

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dijudicant. Secundo, proprio accessus et recessus artificioso motu, quem dixere titubationis, completam revolutionem in 7000 annis absolvendo. Hujus autem motus qualitatem, longum nimis ac taedosium, et huic loco dissonum esset, sigillatim exprimere: consule itaque Purbachium, vel nostrum Albertum Pighium."

[242] (Fine 1532, I.5, 106r): "Albategni vero diligentissimus cum philosophus tum mathematicus, stellas fixas unam circuli partem in quibuslibet 66 annis peragrare, nobis pro certo dereliquit: et quotannis moveri 54 secundis, 32 ter, 43 quar, 38 quintis, et 20 sextis. Cuius opinionis meminit idem Joannes Regiomontanus propositione 6, ejusdem septimi Epitomatis, et quasi eidem assentire, atque eundem Albategni inter alios plurimi facere videtur. Hanc quoque mentem Albategni Augustinus Ricius, vir sanequam eruditus, adeo vivacibus argumentis, gravibus authoritatibus, et firmissima observationum concordantia, nuper sustinere conatus est: ut eandem opinionem veritati propriorem, et inter reliquas magis apparentem judicare cogaris."

[243] On discussions concerning the epistemological status of astrology prior to Fine, see (Chaps. 3 and 4).

[244] Fine then plays with the double meaning of *titubatio*, which both refers to the motion of trepidation of the equinoxes and to the action of staggering, wavering, or simply hesitating.

[245] (Fine 1532, I.5, 106r): "Nolumus enim super hoc inopinabili motu (quemadmodum cum caeteris aliquando fecimus) ulterius titubare: utpote, qui opinionem hanc omnium debilissimam, ne dicam falsissimam, a pertinacissimis et indoctissimis illius sectatoribus perperam etiam intellectam, atque non sine maxima jactura mortalium judiciariam evertentem Astronomiam, cogente ratione fatemur, et recognoscimus. Neminem enim scio (ni prorsus orbatum Philosophia) qui nesciat motum illum tam irregularem cuilibet coelestium repugnare corporum: veluti praefatus Augustinus Ricius, proprio demonstrat opusculo." See also (Ricci and Fine 1521, 25v–26r): "*Confutatio praememoratae juniorum opinionis.* Hunc itaque in modum explicata istorum opinione, ad ejus destructionem accedendum est. Omnium enim (quod pace multorum dictum sit) falsissima esse videtur: quam primo, ex naturali philosophia sumptis rationibus, expugnabimus, postea ad mathematicas probationes reccurremus: ultimo rationibus, quibus hanc opinionem probare conantur, respondentes, totam ruere sententiam plane videbis. Motus itaque accessus, atque recessus in corpore coelesti, eo modo quo in octavo ponitur orbe, dari minime potest: tum primo, quia est motus admodum alienus, ab eo qui circularis dicitur, quem quidem proprium esse caelo omnis philosophia solet affirmare: patetque hoc primo Coeli. Dicunt enim isti juniores capita arietis, et librae imaginum tantum, hoc motu describere parvos circulos circa capita arietis, atque librae signorum, immobilium in nona sphaera existentium: capita autem haec, duo sunt indivisibilia puncta: caeterae vero partes totius firmamenti, nullo modo circulum, sed dissimiles magis, tortuosasque figuras

This argument is far from secondary here, given that judicial astrology, as the part of astronomy whose aim is to determine the influence of celestial motions on the events of the sublunary world, was, as mentioned earlier, regarded at the time as an important part of the activity of astronomers (and of mathematicians in general) within the community; it represented, for most people, one of the main incentives to study astronomy and mathematics in general. The fact that the *Cosmographia* contains several sections on astrology and on the casting of horoscopes confirms that this was not, to Fine, an anecdotic part of the astronomer's activity. For that matter, Fine openly admitted the influence of celestial motions on sublunary events, considering the motion and light of stars to be the intermediaries by which the virtues of the celestial world are diffused into the sublunary world, as set forth in the chapter II.10 of the *Cosmographia*[246] and in his works pertaining more specifically to astrology, such as the *Canons des ephemerides*[247] and the *De duodecim caeli*

describunt: Ita quod nulla stellarum fixarum, quae potissimae, nobilioresque coeli partes esse dicuntur, hoc motu circulum describat mirabile, dij immortales, quidpiam videtur, eos credidisse hunc motum eo se modo habere, ut circularis nulla ratione dici possit, quum ejus orbis nulla fit pars quae circulum perscribere possit. Velle autem tam vasti corporis lationem appellare circularem, eo quod duo dumtaxat in eo puncta sub circulo volventur, dementiae potius, quam rationis esse videtur, etenim nono meta. patet denominationem fieri non debere nisi ab immediato subjecto vel forma: motus autem circularis, necnon et rectus, et si qui alij sunt motus, non a subjecto, sed a forma motuum denominari solent: circularis scilicet eo, quod mota puncta circulares formas, rectus vero, quia sic lata puncta rectilineas describere videntur: si itaque totius motus firmamenti forma conspecta fuerit, non erit circularis: talis enim a circulo quem universa, quae in subjecta sphaera sunt, puncta describere solent denominatur: quod in hoc trepidationis motu minime accidit, nisi in prefatis duobus punctis."

[246] (Fine 1532, II.10, 117r): "ipsa videlicet sydera alium et alium influentiarum effectum in haec inferiora jugiter imprimere, secundum quod aliam et aliam ad totum Coelum obtinent habitudinum, diversoque radiorum influxu haec eadem afficere videntur inferiora." See also (Fine 1542a, 24r): "Quemadmodùm astra propria et intrinseca latione singula Zodiaci peragrando signa, pro varia suorum radiorum in haec inferiora projectione, propriae virtutis sive naturae potestatem multis diversisque modis his rebus imprimunt inferioribus: haud dissimiliter ad primum et universalem motum, veluti partes ipsius Universi, dietim circunducta, pro diversa eorundem syderum irradiatione…horum rursum inferiorum qualitates sensibiliter immutant;" (Fine 1555, II.12, 18v): "Quemadmodùm astra propria et intrinseca latione singula Zodiaci peragrando signa, pro varia suorum radiorum in haec inferiora projectione, propriae virtutis sive naturae potestatem multis diversisque modis his rebus imprimunt inferioribus: haud dissimiliter ad primum et universalem motum, veluti partes ipsius Universi, dietim circunducta, pro diversa eorundem syderum irradiatione…horum rursum inferiorum qualitates sensibiliter immutant" and (Fine 1553a, 4r–v): "Nam quemadmodum sydera (potissimum errantia) Zodiacum ipsum gradatim perambulando, pro diversa suorum radiorum in haec inferiora projectione, proprias vires imprimere, naturalesve potestates multifariam exercere videntur. Non aliter ad universalem motum caeli (quem diurnum, sive primum appellant) absque intermissione revoluta, diversas irradiationes, tum ascendendo super horizontem, aut sub illo descendendo, tum ipsum praeterlabendo meridianum, intra diem naturalem censentur contrahere: et horum propterea inferiorum qualitates, sive naturas, pendenter immutare." On this issue, see (Mosley 2009).

[247] (Fine 1543a, § 17, sig. B5v–6r): "tout ainsi que le Soleil et la Lune et les cinq planetes, faisant leur revolution par leur propre mouvement sous le zodiac, causent divers effects et sensibles mutations es choses inferieures et terrestres, selon la diverse projection de leurs raiz, et diverse disposition des choses naturelles de ça bas, en peragrant de signe en signe, et selon la nature accidentale

domiciliis.[248] All this hints to the expectations of students as well as of the audience of the royal lecturers with regards to the purpose of astronomy as it had been the case for the students of the Faculty of the Arts with respect to the study of Sacrobosco's *Sphaera*.[249]

One of the main problems posed to astrologers by the admission of starless spheres was the complexity this added to the computation of the positions of planets with respect to the zodiacal signs. This matter already raised concerns in relation to the admission of the precession of the equinoxes, since the fact of attributing to the visible stars a proper motion from west to east along the poles of the ecliptic, in addition to the diurnal motion of the universe (as was taught in the *Tractatus de sphaera*), called into question the possibility of using the firmament as an immobile system of reference to calculate the motions of the planets and to determine their positions and conjunctions in relation to the signs of the zodiac. Therefore, astronomers posited the existence of another set of constellations on the ninth sphere, which would be the invisible images of the constellations of the eighth sphere and which served as a system of reference to determine the positions of the planets and the proper motion of the visible constellations.

As shown by discussions that were raised on this issue since antiquity,[250] this practice was not only a problem in view of the invisibility of the constellations of the ninth sphere, which made it difficult to use these constellations as a system of reference in order to determine the motion of the planets and of the visible constellations, but also because these invisible stars were attributed an influence on the inferior bodies or at least an impact on the influence of the planets according to their position relatively to these invisible signs. Astrologers, therefore, had to take into account the influence of these invisible signs in their astrological predictions, which would introduce additional complications in the establishment of astrological charts. For example, certain medieval astrologers, such as Pietro d'Abano (ca. 1257–1316) in the *Conciliator differentiarum philosophorum* (Pietro d'Abano 1520, 14r), attributed an influence to both the visible signs and the invisible signs,

desdits 12 signes du zodiac: pareillement lesdits luminaires et planetes, en tournant environ et au tout de la terre par le premier et universel mouvement de tout le monde, d'orient par le mydi en occident, dedans le temps et espace de 24 heures (que nous appellons jour naturel) causent de rechef tous les jours de l'an divers et particuliers effects selon qu'ils sont en orient ou occident, et notablement eslevez ou deprimez sous la terre, et qu'ils ont plus forte ou debile irradiation sur lesdites choses de ça bas."

[248] (Fine 1553a, 4r): "Nam quemadmodum sydera (potissimum errantia) Zodiacum ipsum gradatim perambulando, pro diversa suorum radiorum in haec inferiora projectione, proprias vires imprimere, naturalesve potestates multifariam exercere videntur: Non aliter ad universalem motum caeli (quem diurnum, sive primum appellant) absque intermissione revoluta, diversas irradiationes, tum ascendendo super horizontem, aut sub illo descendendo, tum ipsum praeterlabendo meridianum, intra diem naturalem censentur contrahere: et horum propterea inferiorum qualitates, sive naturas, pendenter immutare."

[249] On the relation between astrology and cosmography in the sixteenth century (as considered through the case of academic and courtly environment of Louvain), see (Vanden Broecke 2003, 113–18 and 129–33).

[250] On these earlier discussions, see (Duhem 1913–1959, II, 191–92).

and considered that the influence of the signs of the zodiac was stronger when the visible and the invisible signs were superposed (Chap. 4).[251] But as the signs of the ninth sphere are invisible, it would be very difficult in practice to decide when the superposition takes place. Hence, for Fine, the fact of rejecting the existence of starless spheres (and of partially rejecting the cosmological system adopted by Sacrobosco) was not only a question of safeguarding Aristotelian cosmology, but also a question of guaranteeing the validity of the calculations and of the predictions of astrologers.

Although this argument only makes a small appearance in Fine's rebuttal of the existence of starless spheres, it would be highly significant in this context and may have even been his main incentive to reject starless spheres.[252] This could very likely have been the case for Ricci himself, who was a court astrologer at Casale Monferrato and, as mentioned above, a friend of Cornelius Agrippa (Johnson 1946; Goodrick-Clarke 2008). Indeed, in his *De motu*, Ricci clearly questions the ability of the more recent astrologers to offer a solid prognostic on the basis of the nine- or ten-sphere system, denouncing thereby the damage these systems caused to the practice of judicial astrology.[253] This argumentation seems to have been influenced by the *Disputationes adversus astrologiam divinatricem* of Giovanni Pico della Mirandola (1463–1494), who, in book VIII of this treatise, used the uncertainty concerning the numbers of the celestial spheres and the problems raised by the admission of immobile and invisible signs as additional arguments to dismiss judicial astrology.[254] Ricci referred to this discourse in the above-mentioned section of his *De motu*

[251] As shown then by Duhem (Duhem 1913–1959, IV, 239–40), this conception is not original, since it was beforehand expounded by Bernard of Trilia, disciple of Albertus Magnus, in his *Questions* on Sacrobosco's *Sphaera* (Sacrobosco n.d., f. 75, col. d).

[252] With regards to the question of the place of astrology in the cosmological reforms of the sixteenth century, see (Westman 2011).

[253] (Ricci and Fine 1521, 20v–21r): "…nec contineri quicquam veritatis, nisi forte id casu quoddam acciderit in hisce praedictionibus, quae juxta signa novae vel decimae sphaerae, vel immobilia fiunt, cujusmodi sunt juniorum mobile coeli imagines omnino negligentium universa pronostica. Hincque videtur illud esse, quod tam pauca in hodiernis pronosticis comperiantur vera, cum omnes (Arabibus quibusdam exceptis) errantes stellas illuc locare nituntur, ubi imnime consistunt. Nec in locandis nituntur, ubi minime consistunt. Nec in locandis duntaxat sideribus eos errare affirmamus: sed etiam in revolutionum ascendentibus a veritate tantum discedere deprehenduntur, quantum inter quamlibet radicem atque revolutionem octava sphaera proporio motu lata fuerit, tantoque ampliorem fieri errorem, quanto a sua quaque radice, loco solis uti oportet: qui quoniam non est ubi isti imaginantur, ideo nec talis coeli pars oriri potest, qualem isti ex loco solis excerpere conantur, sed tot amplius, minusve partium oriri necesse erit, quot inter caput mobilium vereque existentium signorum, et caput eorum, quae imaginationis ope adinventa sunt, partes fuerint."

[254] (Pico 2005, 642–47): Cap. I: "Incertum esse numerum corporum superiorum, penes quae iuxta astrologos fati decernendi potestas est;" Cap. 2: "Si supra octavam sphaeram alia sit, falsam esse veterem astrologiam, si nulla, quam si sit, nona ruere omnino necesse est." A good synthesis of Pico's critical approach to judicial astrology, and especially to the practice of fifteenth-century Italian astrologers (though not specifically on the impact of the nine- or ten-sphere systems on judicial astrology), see (Vanden Broecke 2003, 55–80).

(Ricci and Fine 1521, 18r, 21v),[255] yet not in order to dismiss the validity of astrology, but rather to dismiss the systems postulating nine or ten spheres.

Yet whether or not this was the main incentive for Fine's rejection of starless spheres, this discussion was also an occasion for him to reassess the traditional representation of the cosmos in its relation to the principles of Aristotelian natural philosophy (which were followed by Sacrobosco with regard to the general structure of the cosmos and the nature of the elements) as well as of the role of the astronomer in determining the physical order of the universe.

With respect to the function of the starless spheres in the astronomer's apprehension of the celestial order, an apparent tension however emerges in Fine's discourse in the *Cosmographia*, since although he partly based his dismissal of starless spheres on their incompatibility with the principles of natural philosophy, he concluded chapter 5 (immediately after asserting the absurdity of trepidation) by conceding the usefulness of the astronomer's fictions to account for the irregularities of the visible motion of the stars.

> So all the things which the wisest astronomers have thought up above the eight sphere were only the imagination of immobile circles, through which they were able to regulate the motion of the Firmament and of the other orbs which are inferior to it. The same judgement should be passed on the particular orbs of the errant stars—that is, the epicycles and the eccentric spheres, and their very particular motions—as well as on similar inventions. These were subtly invented for the sole purpose of saving the apparent variety of each motion and to render the quantity of their irregular motions computable by the power of geometry.[256]

This discourse held an important place in Fine's thought, as it first appeared in the *Theorique des cielz* at the beginning of the chapter on the motion of the eighth sphere (Fine 1528, 33r–v)[257] and came up later on several occasions, notably in the

[255] (Ricci and Fine 1521, 21v): "Huc accedit sicut quam optime dicit Jo. Picus Mirandulanus in eo libro, quem in astronomos confecit, quod scilicet quicquid antiqui de signorum naturis tradiderint, hoc de signis veris octavae sphaerae experti sunt."

[256] (Fine 1532, I, 5, 106r): "Quicquid ergo prudentiores Astronomi super octavum orbem finxerunt, fuit sola immobilium circulorum imaginatio: ut per ipsos, et Firmamenti, et reliquorum inferiorum orbium motus regulare valerent. Idem quoque habendum est judicium, de particularibus errantium syderum orbibus, utpote epicyclis et eccentricis, atque tam diversis eorundem motibus, et his similibus inventis: quae solum ad salvandam evidentem singulorum motuum varietatem, et redigendam ad calculum irregulatum eorundem motuum quantitatem, ex ubertate Geometriae sunt admodum subtiliter excogitate."

[257] (Fine 1528, 33r): "il a esté imaginé par les modernes Astronomes un mouvement composé de trois particuliers, point le mouvement de la huitiesme sphere: dont l'un est attribué au premier mobile, ou quel est l'eclyptique fixe, et est le regulier mouvement de vingt quatre heures: l'autre est attributé à la neufiesme sphere, imaginee entre ledit premier mobile et le firmament: lequel mouvement est d'Occident en Orient, au long du zodiac fixe: Le tiers est une maniere de titubation, propre à ladicte huitiesme sphere: laquelle titubation a esté excogitee pour reformer la variété et irregularité du mouvement dessusdit, comme l'on a faict par epicycles et eccentriques aux sept planetes."

second edition of the *Cosmographia* (unabridged version),[258] but also in the 1532 edition of the *Cosmographia* when dealing with the sun's *theorica.*[259] It was also put forward in an unfinished manuscript draft of a work entitled *Speculum astronomicum* (Fine n.d.), which was intended to present the theoretical principles, the mode of fabrication, and the use of an instrument to determine planetary positions, and which directly referred to the *Cosmographia*. As Fine indicated in this text, starless spheres would have the same status as Ptolemy's epicycles and eccentric spheres,[260] all corresponding to abstract geometrical devices used by astronomers to account for the apparently irregular motions.

> What one generally needs to know first is that all the things which the wisest astronomers have imagined concerning the number, the figure and the various motions of the celestial orbs have only been so in order to calculate the apparent irregularity of the celestial motions. And nobody would think (aside from he who is entirely deprived of philosophical knowledge) that each of these things really exists, since they were only invented through a geometrical and purely imaginary theory so that the true motions of the stars could be obtained. Indeed, the particular orbs of the heavens, which move around the center of the world (as may be seen from the *Theory of the planets*) would be about twenty-six, that is, leaving aside the epicycles and small orbs situated around them, which are adapted to the diversity of the motions. We have shown sufficiently clearly in the first book of our prior *Cosmographia*, and we will reveal it elsewhere in a more complete treatise (if God allows it), how absurd and directly alien to philosophers it is to admit their existence. We have to concede, therefore, whether we want it or not, that the divine and incomprehensible wisdom

[258] (Fine 1542a, 3r): "Nec supra Firmamentum, aut claritate syderum, aut aliqua convincente ratione, Caelum aliquod mobile imaginari compellimur: ni forsitan circulos aliquot immobiles, eruditiones aut calculi gratia, nobis effinxerimus. Octonario igitur cum Platone, Aristoteles, Ptolemaeo, caeterisque probatissimis authoribus (qui circa motus astrorum philosophati sunt) mobilium orbium erimus contenti numero;" (5r): "Quàm absurdum igitur et à rectè philosophantibus alienum sit, contra naturalem rerum ordinem, nulla cogente vel ratione vel experientia, novos supra Firmamentum somniare mobiles orbes (nisi id gratia lucidioris effingatur intelligentiae) cuivis sanae cogitationis relinquimus dijudicandum. Quiquid enim super octavum orbem prudentiores excogitarunt astronomi, fuit sola circulorum ad contemplationem motus ipsius octavi orbis necessariorum imaginatio. Idem quoque velim habeas judicium, de peculiaribus errantium syderum lineamentis, circulis, aut orbibus (quibus tota referta est planetarum theorica) et his similibus inventis, ad contemplandam apparentem in motibus diversitatem, et in fideliorem aliquem calculum redigendam, ex ubertate Geometriae subtiliter admodùm excogitates."

[259] (Fine 1532, IV.1, 131r): "theoricam motus ipsius Solis, ad salvandam, supputandamque motus eiusdem Solis circa Mundi centrum observatam irregularitatem subtiliter excogitatam."

[260] This is also perhaps the case, for Fine, for the circles that divide the worldly sphere, which are defined in the second book of Sacrobosco's *Sphaera* as imaginary. Indeed, there is a certain ambiguity in the *Cosmographia* as to whether these "spheres thought up above the eighth sphere" and which "were the imagination of immobile circles" correspond, for Fine, to the starless spheres—namely to the fixed zodiac and to the *primum mobile*—or rather to the great circles dividing the worldly sphere according to Sacrobosco's *Sphaera*, such as the equinoctial and the colures. Yet in the *Theorique des cielz*, trepidation (and thus the starless sphere its admission led to postulate) is explicitly described as a fiction invented by astronomers to account for the irregularity of the motions of the stars and assimilated in this respect to the partial orbs; (Fine 1528, 33v): "laquelle titubation a esté excogitee pour reformer la variété et irregularité du mouvement dessusdit, comme l'on a faict par epicycles et eccentriques aux sept planets." It remains, in any case, clear that Fine also reduced, in the *Cosmographia*, the starless spheres to geometrical fictions, just as he did for epicycles and eccentric spheres.

kept to itself the eternally admirable quality of the celestial motions, but has, in its merciful benevolence, granted to men the ability to apprehend and eventually calculate the quantity of these motions through a geometrical and abstract discourse."[261]

This passage was entirely crossed out in the manuscript, but was initially placed within the first proposition of the treatise and shows Fine's eagerness at this point to discuss the ontological status of the constructions necessary for astronomers to calculate and predict the apparent positions and trajectories of stars. As he explains it then, if starless spheres (as well as partial epicycles and eccentric spheres) are not physically real, they would be regarded as useful by astronomers for determining the positions and trajectories of the stars and planets, given that the human mind was not endowed by God with the ability to apprehend the true quality of the celestial order, though it was made able to access the true motions of the stars—that is, their visible position from the earth at any moment of their cycle—by means of geometrical and abstract devices.

Therefore, if, on one hand, Fine invited astronomers in the *Cosmographia* to dismiss starless spheres because they contradict the principles of natural philosophy and because they introduce unnecessary complexity into the practice of astrologers, he acknowledged, on the other hand (in this text as in the *Cosmographia*), the utility of such fictions, alongside epicycles and eccentric spheres, to account for the visible celestial motions, since the true causes and structure of these motions would remain incomprehensible and thus hidden to the human mind.

Yet from what Fine said in the *Cosmographia* in reference to Ricci's *De motu*, this would not justify the admission of starless spheres beyond the starry heaven, since he held them not only as contradictory to the principles of natural philosophy, but also as mathematically irrelevant, since they would not be necessary to account for the variety of the motions of the fixed stars. Furthermore, he considered starless spheres as certainly more problematic than partial orbs in regard to the validity of judicial astrology, given that the knowledge of the motion of the fixed stars is more important to determine the true positions of planets in relation to the zodiacal signs than the causes of their stations and retrogradations.

Hence, although the astronomer would not be able to fully access the true order of the heavens, he should, to the extent of his abilities, still attempt to determine the nature of celestial substances as much as it is possible by always choosing the hypothesis that is most simple and best conforms to the principles of natural

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[261] (Fine n. d., 4v): "In primis itaque illud in universum est notandum: quicquid prudentiores astronomi de multiplici coelestium orbium numero, figura, et motu sunt imaginati, ad supputandam observatam coelestium motuum irregularitatem fuisse tantummodo repertum. Neque putet quispiam (in forsitam orbatus philosophia) singula re ipsa constare, quae geometrica, et pure imaginaria ratiocinatione, ut veri syderum moti obtinerentur, solum excogitata sunt. Essent enim particulares coelorum orbes, mundi centrum ambientes, (ut ex planetarum licet videre theorica) numero circiter 26; etiam praeter epyciclos, et circumpositos orbiculos, ad motuum varietatem convenientes. Quòd quàm absurdum, et à recte philosophantibus alienum existat, libro primo noster precedentis Cosmographiae, et alibi satis aperte mostravimus, et pleniori tractatu (se concedat altissimus) elucidaturi sumus. Confiteamur igitur, velimus nolimus oportet, Divinam illam et incompraehensibilem sapientiam, coelestium motuum semper admirandam sibi reservasse qualitatem: hominibus tamen, sua clementi bonitate, hanc contulisse gratiam, ut geometrico, et abstractivo discursu, praedictorum motuum quantitatem obtinere, tandemque supputare <hujusce> valerent."

philosophy. This is why, in the *Theorique des cielz*, although Fine taught Peurbach's theory of planetary motions and expounded the motion of trepidation, referring in this process to separate spheres for both precession and trepidation (as Peurbach had done), he represented the heavens as divided into only eight spheres at the beginning of the treatise (Fine 1528, 3r), just as he did in the frontispiece of the 1527 edition of Lefèvre's commentary on the *Sphaera* and in the various editions of the *Cosmographia*.

What Fine then seemed to condemn in the *Cosmographia* and in the *Speculum astronomicum* is not so much the use of geometrical fictions for calculational purposes, but rather the fact of admitting them as physically real and also of appealing to them, even as calculational devices, when these are not necessary to account for the apparent motions of the heavens, especially when they have a role to play in the determination of the planets's influence in the framework of judicial astrology, as in the case of the ninth sphere.

This discussion, therefore, brings forth the vexed issue of the reality and of the function premodern astronomers attributed to partial orbs and starless spheres in the description of the celestial order, be it according to the model defended by Sacrobosco or that transmitted by Peurbach.[262] Now, if, in view of the incompatibility of the Ptolemaic astronomical model with the principles of Aristotelian natural philosophy, certain astronomers and philosophers restricted these models to mere calculational devices, which would only be fit to predict the apparent positions of the stars from the earth and to cast tables of ephemerides, this cannot be straightforwardly interpreted as a sign that they did not attribute to astronomy the right and the duty to investigate and to describe the true order of the heavens to the extent that it is humanly possible.[263] This is marked in particular by Ptolemy's will to maintain the circularity of celestial motions and by his physical account of partial orbs in the *Planetary hypotheses* (Goldstein 1967; Morelon 1999), which was known to the Latin medieval and Renaissance astronomers through derived Arabic cosmological accounts (Lerner 1996, I, 94–99) (Chap. 6). As shown in particular by Peter Barker, there are also various examples, in the Middle Ages and in the precopernican Renaissance, of astronomers attributing physical reality to partial orbs and starless spheres (Barker 2011) (Chap. 6). This may also be confirmed by the fact that, in *Almagest* XIII.2, Ptolemy dismissed the opinions of those who rejected certain astronomical models (notably his own) on account of their complexity by qualifying the ability of the human understanding to decide on the degree of simplicity that is appropriate to divine realities (as celestial bodies and motions were considered to be) on the basis of what is simple in the elementary world.[264] This discourse of Ptolemy

[262] This is the great question raised by P. Duhem, in *Σῴζειν τὰ φαινόμενα* (Duhem 1908), in which he deploys an instrumentalist interpretation of precopernican astronomy.

[263] This has been shown by several historians of astronomy in the last decades, among which (Lloyd 1978; Jardine 1979, 1982; Westman 1980; Barker and Goldstein 1998; Morelon 1999; Barker 2011).

[264] (Ptolemy 1984, XIII.2, 600): "Now let no one, considering the complicated nature of our devices, judge such hypotheses to be over-elaborated. For it is not appropriate to compare human [constructions] with divine, nor to form one's beliefs about such great things on the basis of very

did not intend to fully validate the physical reality of his cosmological system, but it certainly aimed to restrict attacks on its physical possibility.

For Fine as well, the fact that it is not possible for the human mind to grasp the true quality of celestial motions in no manner means that the astronomer should not, as much as possible, attempt to investigate and describe the true order of the cosmos. This is not only indicated by his assertion of the physical impossibility of starless spheres and by his will to maintain an eight-sphere system in the general structure of the heavens (even in his adaptation of Peurbach's *Theorica*), but is also suggested by his definition of astronomy in the preface of the 1532 edition of the *Cosmographia*, where astronomy (then specifically identified as theoretical or mathematical astronomy) is said to study the "celestial globes, stars, their motions, their accidents and things of the kind,"[265] and more generally "the celestial body itself, the most illustrious of all bodies, which is absolutely deprived of alteration, is situated in the highest place, is the noblest and is endowed with circular motion, that is, with the first and most perfect of all motions,"[266] a description which is derived from the Aristotle's *De caelo* and which states the physical qualities of the celestial body. Moreoever, even if Fine's rejection of starless spheres was primarily motivated by the will to safeguard astrology, this motivation never seems entirely separate from the will to determine the real position of the fixed stars in relation to the earth and the planets, since the very influence of the planets (itself considered physically real)—in other words the action operated by their light, heat, and motion (plus

dissimilar analogies. For what [could one compare] more dissimilar than the eternal and unchanging with the ever-changing, or that which can be hindered by anything with that which cannot be hindered even by itself? Rather, one should try, as far as possible, to fit the simpler hypotheses to the heavenly motions, but if this does not succeed, [one should apply hypotheses] which do fit. For provided that each of the phenomena is duly saved by the hypotheses, why should anyone think it strange that such complications can characterise the motions of the heavens when their nature is such as to afford no hindrance, but of a kind to yield and give way to the natural motions of each part, even if [the motions] are opposed to one another? Thus, quite simply, all the elements can easily pass through and be seen through all other elements, and this ease of transit applies not only to the individual circles, but to the spheres themselves and the axes of revolution. We see that in the models constructed on earth the fitting together of these [elements] to represent the different motions is laborious, and difficult to achieve in such a way that the motions do not hinder each other, while in the heavens no obstruction whatever is caused by such combinations. Rather, we should not judge 'simplicity' in heavenly things from what appears to be simple on earth, especially when the same thing is not equally simple for all even here. For if we were to judge by those criteria, nothing that occurs in the heavens would appear simple, not even the unchanging nature of the first motion, since this very quality of eternal unchangingness is for us not [merely] difficult, but completely impossible. Instead [we should judge 'simplicity'] from the unchangingness of the nature of things in the heaven and their motions. In this way all [motions] will appear simple, and more so than what is thought 'simple' on earth, since one can conceive of no labour or difficulty attached to their revolutions."

265 (Fine 1532, 102v): "…consyderat Astronomia, utpote, coelestes globos, sydera, eorum motus, et passiones, ac ejuscemodi."

266 (Fine 1532, 102r): "Nam subjectum Astronomiae est ipsum coeleste corpus, inter omnia corpora praestantissimum, omni prorsus alteratione privatum, supremo et nobiliori loco, motuque circulari omnium motuum priori ac perfectiori decoratum."

occult influences, when they were admitted) on the events occurring in the elementary world—is determined by their disposition in relation to the zodiacal signs.[267]

The discourse presented by Fine in the first edition of the *Cosmographia* concerning the number of celestial spheres thus shows that, in the context of a teaching on the sphere tacitly based on Sacrobosco's *Sphaera*, which he approached with the intention of offering a properly up-to-date and complete teaching of its theoretical and practical aspects, he considered it important to establish the representation of the cosmos on a physically acceptable foundation, in particular as it played a crucial role for him in asserting the validity of astrology.

Rejecting in this manner the general structure of the universe and the type of celestial causality (*raptus*) defended by Sacrobosco, among many others, Fine's *Cosmographia* demonstrates again the openness of the textual design of the *Tractatus de sphaera*, which allowed the transformation of various part of its content, notably concerning its cosmological stances, without disturbing the general structure of its teaching on the theory of the sphere (Oosterhoff 2015; Valleriani 2017).

6 Conclusion

The relation between Oronce Fine's astronomical work and Sacrobosco's *Sphaera*, from the edition of the *Sphaera* in 1516 to the *Cosmographia* in 1532, instantiates the royal lecturer's various talents as a mathematician, a professor of mathematics, a cartographer, a maker of scientific instruments, an editor, and an engraver. Through his early contributions to the diffusion of the *Sphaera* in a format accessible to students, Fine demonstrated his active commitment to the mathematical curriculum of the Faculty of the Arts in his first teaching years at the Collège de Navarre. As he started to teach mathematics as a royal lecturer about fifteen years later, he offered his new audience a renovated teaching of spherical astronomy rooted in Sacrobosco's *Sphaera*, in which he included the practical notions necessary to its application in judicial astrology, cartography, nautical geography, and dialing. Given the strong emphasis Fine placed on practical knowledge in the *Cosmographia*, this work constituted an important element of his project to transform the traditional mathematical curriculum.

In its relation to the *Sphaera*, the *Cosmographia* cannot be straightforwardly considered a commentary since it does not feature Sacrobosco's text. However, it integrated many aspects of Sacrobosco's teaching in its content and format, for which Fine's treatise could be considered an appropriate alternative to the *Sphaera* in certain teaching programs of sixteenth-century institutions. For that matter, if Fine innovated on his 1516 edition of Sacrobosco's *Sphaera* with regard to the layout of the text and by the inclusion of a few tables,[268] the *Cosmographia* offered a complete renovation of the content of the traditional teaching of spherical astronomy from which the very name of Sacrobosco is entirely absent.

[267] On the relation between astrology and cosmology in the sixteenth century, see also (Chap. 5).

[268] On innovations of this type, see (Chap. 9).

Within the *Protomathesis*, the theory of the sphere appears as a core teaching, demonstrating the necessity of arithmetic and geometry to study astronomy while providing the necessary principles for the study and practice of cartography, judicial astrology, and gnomonics. The relation of the *Cosmographia* to the other parts of Fine's mathematical teaching, as well as his recurrent assertion of the higher necessity of astronomy for the contemplation of the Creation and of the Creator himself, thus allowed him to present this discipline as the crowning of the traditional quadrivium, as well as the condition of its fruitfulness.

The *Cosmographia* was also the occasion for Fine to express his opinion on the order of the cosmos and on the relation between mathematics and natural philosophy, as was the teaching of Sacrobosco's *Sphaera* for several of its commentators. Showing the importance of offering a correct cosmological system in order to safeguard astrology, given its dependence on the knowledge of the true relation of the planets to the zodiacal signs, Fine also addressed the expectation of many students of the Faculty of the Arts at the time with regard to the applications of astronomy and of Sacrobosco's *Sphaera*, notably for the practice of medicine.

Fine's *Cosmographia*, which represented a means of disseminating Sacrobosco's teaching on the sphere that differed in its form and intention from proper editions and commentaries on the *Sphaera*, also gives us an illustration of the various manners in which the content of this thirteenth-century elementary treatise was adapted to the needs of the sixteenth-century reader and how it contributed to the transformation and to the promotion of mathematical teaching in Renaissance France. While the name of Sacrobosco did not explicitly appear in works such as Fine's *Cosmographia*—which in Fine's case reveals an ambiguous relation to a source he himself edited and taught during his years at the Collège de Navarre—, the *Sphaera* remained a clearly identifiable and stable source at the time for the study and the application of the theory of the sphere, through which it was able to maintain, in European academic and non-academic scientific culture, the status of universal reference for the introductory teaching of astronomy until the seventeenth century.

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