The Hidden *Praeceptor*: How Georg Rheticus Taught Geocentric Cosmology to Europe

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A corpus of 360 distinct early modern printed editions (from 1472 to 1650) containing Johannes de Sacrobosco's Tractatus de sphaera *is "dissected" into a corpus of 540 text-parts, 241 of them re-occurring at least once. Through the exploration of the data, we recognized a relevant position for four anonymous authors in their social network. We demonstrate that the text-parts originally assigned to the anonymous authors were authored or edited by Georg Rheticus. By means of data analysis, we conclusively establish that Rheticus profoundly impacted the content of such textbooks for the introductory class in geocentric astronomy all over Europe between 1538 and 1629.*

The present research has been conducted in the frame of the project "The Sphere. Knowledge System Evolution and the Shared Scientific Identity of Europe" at the Max Planck Institute for the History of Science (https://sphaera.mpiwg-berlin.mpg.de) and "Images and Configurations in Corpora of University Textbooks" in the frame of BIFOLD (Berlin Institute for the Foundations of Learning and Data: https://bifold.berlin) (ref. 01IS18037A). We would like to thank Elio Nenci (Università Statale di Milano) for his invaluable support concerning the research results presented in the section Anonymous 1538a, parts 1, 2, 3, and 5. We also would like to thank Insa-Christiane Hennen (Leucorea Stiftung, Wittenberg) for drawing our attention to the document preserved at the Ratsarchiv Wittenberg. Finally, we would like to thank Elizabeth Hughes for editing this article.

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1. Wittenberg, 1531

A small printer—Joseph Klug (1490–1552)—completed a new printed edition of the late medieval *Tractatus de sphaera* by Johannes de Sacrobosco (1196–1256) and sold it locally for students at the University of Wittenberg who were attending the Faculty of Liberal Arts (Sacrobosco and Melanchthon 1531). This event appears, at first sight, to be rather irrelevant; since the first printing of the same textbook in 1472, eighty-three editions were printed, and two other editions, besides Klug's, were also printed in 1531. In truth, however, this event started a dynamic that turned Wittenberg into a place of production of university textbooks, triggering the production of textbooks of similar content and design all over Europe. Klug's 1531 edition is the beginning of the emergence of an "epistemic community" of textbook editions that became dominant in Europe.

Our research is based on a corpus of historical sources consisting of early modern printed books that contain, in different forms, a specific treatise on cosmology: Johannes de Sacrobosco's *Tractatus de sphaera*, a university textbook used for a qualitative introduction to geocentric cosmology and first compiled at the University of Paris during the thirteenth century. This corpus, moreover, further collects 126 different editions of university textbooks used for teaching the same subject. They do not, however, contain Sacrobosco's treatise but an introduction to spherical astronomy that follows the same design as Sacrobosco's work, discusses the same subjects in the same order, and at least partially uses the same visual apparatus. In total, 360 different editions were identified between 1472 and 1650, and these were printed in forty different places across the continent of Europe.[1]

Considering a possible and realistic average print-run of about 1,000 copies for each edition (Gingerich 1988), the corpus is representative of approximately 350,000 university textbooks that circulated and were used by students over the course of 180 years across Europe. Because Sacrobosco's text was the most common for an introductory class in astronomy, we can consider this corpus as representative of the basic knowledge in astronomy possessed by the educated citizens of Europe during the early modern

1. The corpus has been collected for the project "The Sphere. Knowledge System Evolution and the Shared Scientific Identity of Europe" (PI: Matteo Valleriani). The collection is available online through the project website: https://sphaera.mpiwg-berlin.mpg.de (accessed March 4, 2021). For the function of this treatise and how it transformed over the centuries (see Valleriani 2017). For a description of the corpus concerning the printing locations of the editions, their book formats, their printers, and publishers, as well as their language (see Valleriani 2020b).

time. The investigation of such a corpus of sources and, in particular, the reconstruction of the transformation processes the content of such textbooks underwent allows us to understand the evolving formation of a common scientific identity in Europe as produced by the growing network of universities.

A previous study (Valleriani et al. 2019) has shown that, starting between 1531 and 1538 (Sacrobosco and Melanchthon 1538), Wittenberg was able to put two new, distinct editions of Sacrobosco's treatise on the market that were "observed" and copied at least partially all over Europe. In other words, the Wittenberg astronomy textbooks were so widely imitated that their content can be regarded as fully hegemonic all over Europe.

Both Wittenberg editions of 1531 and 1538 were printed by the same printer, Joseph Klug, who was particularly close to Philipp Melanchthon (1497–1560) at that time and published many of the Reformer's major theological works. The reason that the Wittenberg editions became so significant can be understood through the content of the textbooks themselves as such textbooks typically contained not only the fundamental treatise of Sacrobosco but also further treatises or fragments thereof, paratexts, and commentaries.

The 1531 edition of Sacrobosco was printed and sold together with Melanchthon's famous letter to Simon Grynaeus (1493–1541). This open letter, which served as an introduction to the work, was a defense of astrology and encouraged his students to study cosmology and astronomy. As several historical case studies have shown, this letter became well known internationally and trans-confessionally, and was republished many times in conjunction with scientific astronomical works (Pantin 1987; Lalla 2003; Reich and Knobloch 2004). In our corpus alone, this letter can be found in fifty-eight different editions. In the book, after the letter, students could find Sacrobosco's original and uncommented text immediately followed by another short composition of Melanchthon. In this case it is a four-verse epigram, *De triplici ortu et occasu siderum*. The students could learn it by heart and thus never forget that there are three ways to consider the rising and setting of the stars: the cosmical, the heliacal, and the achronic.[2] Finally, the work concluded with a fragment (Book 3, Prop. XXII) of the even more famous *Epitome* of Johannes Regiomontanus (1436–1476)

2. The heliacal and cosmical rising and setting of a star take place before and after it has been in conjunction with the sun, respectively from visible to invisible and vice versa. The achronic rising or setting of a star takes place after sunset.

on Ptolemy's *Almagest*.[3] This proposition offers deeper insight into the causes of the different lengths of the days and nights throughout the year. It was reprinted eighty-seven times alone in our corpus and was obviously as widespread as the *Epitome* itself. What was peculiar in this editorial initiative is that all three accompanying texts were published in this form and appended to Sacrobosco's text for the very first time. The strikingly innovative character of this edition was further enhanced by the then still unusual format for textbooks, the *octavo*, which quickly became a standard format all over Europe. Klug reprinted the same work in 1534 and reissued the 1534 edition in 1536 (Sacrobosco and Melanchthon 1534, 1536).[4]

In 1538, however, he produced a new edition that at first glance appears to be an enlargement of the previous ones. Beside the aforementioned texts, it also contains a fragment of al-Farghānī's (d. 861) (*Differentia XXIIII*) *Brevis compilatio astronomica* in which the subject of the rising and setting of the planets is discussed; another open letter by Melanchthon addressed to Achilles Pirmin Gasser (1505–1577), prefatory to the ensuing text; Sacrobosco's *Computus ecclesiasticus*; and a *Cisiojanus*.

Sacrobosco's *Computus* is a calendrical work used to teach students how to calculate the days of the movable feasts of the liturgic calendar in advance. It was very widespread during the thirteenth and the fourteenth centuries and always used together with the work *De sphaera*. In the corpus of the printed textbooks containing *De sphaera,* this edition represents its first appearance. The *Cisiojanus* is a typical medieval work on calendric systems as well, in this case a mnemonic-mechanical aid for remembering the non-movable feasts. It consists of a series of verses to be learned by heart that apparently make no sense unless each syllable is used as an acronym for days and saints of the liturgical calendar (Kully 1974).

Melanchthon's letter to Gasser is particularly relevant for our argument because the theologian informs us that it was actually Georg Joachim Rheticus (1514–1574) who came up with the idea of inserting Sacrobosco's *Computus* into the 1538 edition.

Al-Farghānī's fragment was also printed in this edition for the first time in the corpus, which serves as evidence of the initiative to insert a series of innovations into the corpus in two steps represented by the two editions. In the second step, with the exception of Melanchthon's letter to Gasser, the texts were only considered new because they were printed together with *De sphaera* for the first time. In fact, they were originally produced

3. Regiomontanus' *Epitome* was written in 1463. Its first print was (Regiomontanus 1496).

4. We identified the 1536 edition as a reissue of the 1534 edition through comparing the fingerprints.

between the ninth and the thirteenth centuries. As we have shown elsewhere (Valleriani et al. 2019), it is by means of this second step that Wittenberg achieved high visibility, causing the 1538 edition to become a model.

Looking closer at the 1538 work, however, there is another relevant difference. This is shown by the fact that the original text of Sacrobosco has been changed and especially enriched. The new text is not a standard commentary and no commentator is indicated. This re-edited original text of Sacrobosco is one of the key elements that became most widely imitated in the model.

Further studies of ours (Zamani et al. 2020) have shown that the production of Wittenberg remained a model for over thirty years, while the edition was continuously updated especially with reference to its visual apparatus and was produced by different printers in close contact to each other.[5] In this respect, we were able to identify what we call the great transmitters. These are editions of the corpus that, after a series of innovations, had a lasting impact until the end of the period under consideration. More specifically, we have identified the period of innovation to be between 1531 and 1549. If such editions were reprinted in Wittenberg within the timeframe from 1549 to 1562, then such editions also maintained their impact beyond the first thirty years of epistemic dominance of the Wittenberg model.[6]

This is the background against which the question concerning the authorship of such influential early Wittenberg commentaries emerges. As those commentaries impacted the content of many other textbooks and consequently shaped the scientific identity of Europe, our goal is to identify the minds behind this transregional phenomenon.

2. The Authors of the Commentaries

Investigations concerning the authors of the scientific commentaries and textbooks of the corpus were hitherto limited to the description of the intellectual and institutional profiles of the more relevant scientists among them. Significantly, it turned out that all the early modern authors of the commentaries on Sacrobosco's treatise, without exception, were involved in

5. A similar result has been recently achieved by a different analysis that focuses on the production of *Wetterbuchlein* (Johnston 2020). An analysis of the distribution of the paratexts in the *Sphaera* corpus also reveals that the Wittenberg printers were involved in a continuous mutual exchange of text-parts (Valleriani and Sander 2022).

6. Editions could become great transmitters if they were printed in Wittenberg between 1549 and 1562, but did not necessarily have to be designed and first printed in Wittenberg like Klug's editions. Other works first printed elsewhere and then adopted by Wittenberg's printers also became great transmitters.

teaching the quadrivium (Valleriani 2020a). Assuming that the influence of certain editions over others was due to the prominence of authors of the commentaries, we looked for a method to identify how authors, printers, and publishers became aware of other authors and their works. Such awareness is conceived as the condition that allows for authors to exert an influence or an impact on works of others and therefore for their work to become a model to imitate. To identify these authors, we used tools of the social network analysis in the closest possible relation to our analysis of the historical sources. We first considered all authors listed on title pages of the editions of our corpus. It emerged that no real community could be identified because very few of them could have been in contact with each other. An additional stipulation required that the authors of the commentaries had to have been alive at the time of publication. If more than one living author was listed on each title page, then a potential connection—via printer and publisher—was possible. With this consideration, only six of them (Élie Vinet (1509–1587), Pedro Nuñes (1502–1578), Francesco Giuntini (1523–1590), Pierio Valeriano (1477–1560), Albertus Hero (1549–1589), and Philipp Melanchthon) were aware of each other.

We therefore continued by atomizing all the editions into text-parts. A text-part is a textual passage that cannot be formally smaller than a paragraph and covers a well-defined subject with completeness. A text-part in the corpus of Sacrobosco's *De sphaera*, for instance, is the *Theoricae novae planetarum* by Georg von Peuerbach (1423–1461). This text was first included in the *Sphaera* treatises as early as 1482, and by 1537 it had been reprinted seventeen times in editions of the *Sphaera*. If literary compositions—ordinarily printed in scientific books beginning in the sixteenth century—are considered, a text-part can be much more modest in length. A representative example might be the short *carmen* written by Donato Villalta (1510–1560) and dedicated to the scholar Pierio Valeriano (1470–1560), printed for the first time in 1537 and reprinted a further thirty-two times. Finally, all the texts constituting the 1531 and 1538 editions mentioned above are text-parts.

The corpus in its entirety contains 540 text-parts, which we identified chronologically by publication date and by investigating their authors when they were not listed on title pages. By this means we created a new list of authors of the commentaries that includes not only those credited on the title pages but all those whose texts were effectively printed in the editions under scrutiny. In total, they amount to 222.

Then we looked at the recurrences of the text-parts, considering only text-parts that were published at least twice, with the second publication released no earlier than the year following the first printing. Based on these criteria, 241 text-parts remained, meaning that 324 text-parts were

published either only once or more than once but in the same year. The remaining 239 text-parts recur 1,394 times! Recurrences range from just 1 to a maximum 87.

By considering all the parts and their recurrences and by applying the same condition mentioned above in order to detect potential communities of awareness among authors, we created a new social network.[7] This network is constituted of thirty-four components, while isolated authors are ignored. In confirmation of our results from the aforementioned studies, the main component indeed roughly corresponds to the period of Wittenberg's dominance and of the editions that acted as great transmitters. Many of the authors mentioned in the main component, moreover, were lecturers in Wittenberg or somehow related to that city (See Fig. 1).

We calculated three different parameters of the network: betweenness centrality, closeness centrality, and the simple degree values for all the nodes. Calculating the betweenness centrality identifies those authors who connect different communities within a component. The closeness centrality tells the distance for each node to all the other nodes of the network; the higher the value, the more central its position. The degree reveals the absolute number of edges connected to each node, which in turn tells us which contemporary authors were most frequently published jointly.

The values related to betweenness centrality show that Vinet and Melanchthon occupy the highest position followed by two anonymous authors (Anonymous_1538b and Anonymous_1543b). The closeness centrality values show exactly the same situation, while the degree values place Anonymous_1543b at the top (132 connections), followed by Vinet (124 connections), Melanchthon (122 connections), and by Anonymous_1538b (82 connections).

While the historical roles of Melanchthon and Vinet are well known, the two remaining anonymous authors have not been identified to date. Their texts-parts, which appeared in Wittenberg during the period in question certainly played important roles. The network moreover shows the presence of nine additional anonymous authors. Only two of them are authors of text-parts published in Wittenberg as well. These are Anonymous_1538a and Anonymous_1543a. Their text-parts were published in the same treatises in which the text-parts of the anonymous authors who scored high were also published.

7. The datasets used for this network analysis and the one in the section "Rheticus in the Network of Authors" as well as the data to evaluate its impact in Europe as described in the last section, are all available at https://doi.org/10.5281/zenodo.4593120 (accessed March 10, 2021) to guarantee the reproducibility of our results.

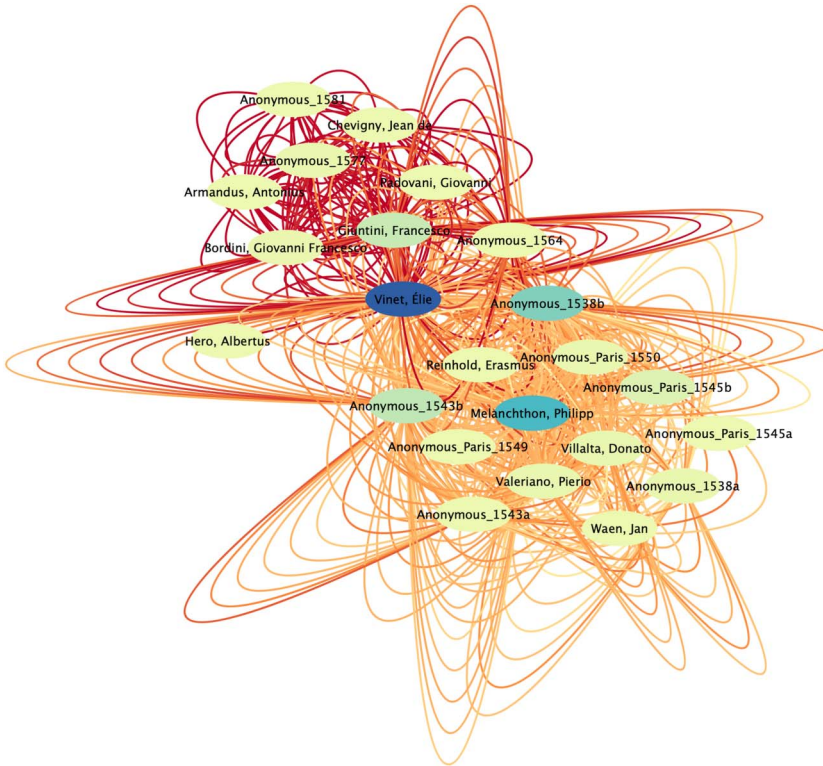


Figure 1. Social network visualization of the text-part authors. The network is not oriented. Betweenness centrality is colored. The tonality of the edge color changes according to the time: the more recent, the more pronounced.

We hypothesize that the four anonymous authors are all in fact the same person, namely, Georg Rheticus. A vague but potential clue to support this theory is given by Rheticus himself in his letter to Paul Eber (1511–1569) on March 1, 1562 (Burmeister 1968, vol. 3, pp. 162–4). Eber asked Rheticus on behalf of the publisher Conrad Ruehel (b. 1528) to edit and prepare a work for printing. In his answer, Rheticus complained that this kind of task was badly paid, and recounted his experience editing and preparing the *Sphaera* and the *Computus* at the request of Moritz Goltz (1495–1548). The latter was a bookseller and publisher who had founded a publishers' association together with Bartholomäus Vogel (1504–1569), and Christoph Schramm (d. 1549) in Wittenberg in 1533. From a document preserved at the Ratsarchiv Wittenberg (RatsAWB 113 (Bc101), Gerichtsbuch 1523–1551, fol 133r), we know that Schramm, and therefore Goltz's

publishers' association, was indeed one of the financial sponsors of Joseph Klug.[8] Therefore, we consider it plausible that Rheticus was referring to his own editorial work on the 1538 edition.

In support of this hypothesis, we will analyze in the following the content of the text-parts of such anonymous authors in order to infer their identity. In conclusion, we will analyze in detail their impact on textbook production in Europe. We begin with the re-edited *Tractatus de sphaera* mentioned by Rheticus himself. This was re-edited twice and published correspondingly in 1538 and 1543. In both cases, the author of the work on the *Tractatus* is not declared, and therefore we assigned authorship first to Anonymous_1538a and Anonymous_1543a.

3. Anonymous 1538a

Anonymous 1538a is the scholar who reworked the *Sphaera* of Sacrobosco printed by Klug in 1538. In the following section, we will show why we believe that this scholar was Georg Rheticus, the scientist who went down in history for bringing Copernicus' *De revolutionibus* to press. This assumption is, in fact, not completely new. Four other scholars have already advanced this hypothesis (Burmeister 1968; Rosen 1974; Kraai 2003; Pantin 2020). Their assumption is based on the established fact that Rheticus was appointed as a lecturer at the University of Wittenberg and, as such, was indeed teaching *De sphaera*. In particular, Jesse Kraai bases his assumption on a manuscript of Rheticus' pupil Nicolaus Gugler (1521–1577) that contains notes of two *Sphaera* classes held by Rheticus between 1536 and 1538 (Guglero 1536–1538, 1r–37r). The conclusions reached by these four scholars, however, are based on general assumptions and not on close readings of the commentary at hand. Moreover, they did not consider the further anonymous works contained in the same treatises, as we will do later in this paper. Finally, and possibly more relevantly, the previous scholars did not notice the impressive impact that such anonymous texts had all over Europe, as it will be shown in the final section of this work.

In the following section, we would like to enrich the general plausible arguments of the previous scholars with a series of new pieces of evidence

8. The editor of the Rheticus correspondence, Karl Heinz Burmeister, came to the conclusion that Rheticus was referring to the 1550 edition of the *Sphaera* published by Krafft. He based his argument on the fact that the publisher Conrad Ruehel, who asked Rheticus through Eber to edit some works in 1562, was apparently also an accountant at Krafft's print shop during those years. But Rheticus referred to Goltz when he mentioned the work on the *Sphaera* and the *Computus*, and Goltz was already deceased by 1548. For Goltz's commercial and financial activities (see Hennen 2022; Limbach 2022).

resulting from the close reading of the historical sources. We shall start by analyzing the textual additions of the 1538 edition in comparison to that of 1531.

3.1. The First Addition

The first addition is at the beginning of the treatise and is made in the text flow, as if it were part of Sacrobosco's original text. It concerns Euclid's definition of the sphere from the fourth century BCE. The interesting aspect here is that the definition is added in Greek. We believe that this addition was a consequence of the 1533 first Greek (with Latin translation) printed edition of Euclid's *Elements*, which was prepared by the aforementioned Grynaeus on the basis of two manuscripts provided by Lazare de Baïf (1496–1547) and Joannes Ruellius (1479–1537), as well as of Bartolomeo Zamberti's (1473–1543) Latin translation published in 1505 (Grynaeus 1533). The proposition added to the *Sphaera* has exactly the same wording of Book 11, def. 12 of Grynaeus' edition. More importantly, the same Rheticus prepared a Greek edition of Euclid's *Elements* (Rheticus 1549) with a Latin translation of Joachim Camerarius (1500–1574), although he only edited the first six books. But we know from Camerarius' dedicatory letter that the work, according to humanistic precepts, was intended both for the study of the *Elements* and of ancient Greek; an approach that may have animated Rheticus to accomplish this addition in 1538.

3.2. The Second Addition

The second textual addition, printed at the margin, is concerned with Proclus' (412–485) commentary on Hesiod's *Works and Days* (verse 565) from the seventh or eighth century BCE. The passage in question is added where Sacrobosco discusses the achronic setting of the stars by using examples from the works of Ovid (b. 43 BCE) and Virgil (70–19 BCE). The marginal comment offers an example from Hesiod (the star Arcturus) and points to the beginning of Proclus' commentary, where it is mentioned that the astronomers developed the achronic method to understand this specific passage of Hesiod which "presumably" refers to sixty days after the winter solstice (Marzillo 2010, pp. 208–9). This comment seems to point to the authorship of Melanchthon rather than of Rheticus, as the former explicitly quotes this work of Hesiod in his letter to Gasser (though not the same verse) and wrote an entire commentary on that specific work of Hesiod, which was published in 1532 (Bretschneider and Bindseil 1843–1860, vol. 18, cols. 158–274). However, a few clues, which will be discussed in the section about the work of Anonymous 1543b, seem to justify the

possibility that Rheticus might be the author of this comment, too, although Melanchthon's influence is undeniable.[9]

3.3. The Third Addition

The third textual addition, another marginal printed comment, refers to al-Farghānī's *Compilatio astronomica* (*Differentia VIII*). The comment lies next to Sacrobosco's discussion of the length of the Earth's diameter. In the comment, the measure of space for each degree of longitude (56 *milliaria* and 1/3) is added together with the source from which this information is extracted: "ex Alfragano." Indeed, exactly the same value is given in the Latin version of al-Farghānī's introductory work on astronomy. This work, divided into thirty chapters (*differentiae*), was a non-mathematical introduction to the *Almagest* by Ptolemy (b. 100), basically the ninth-century Arabic predecessor of Sacrobosco's *De sphaera*. After the twelfth-century Latin translations of John de Seville (1100–1180) and Gerard of Cremona (1114–1187), the work was widely disseminated and extremely influential in the Latin world. While the first printing took place in 1493 (al-Farghānī 1493), the second was produced in 1537 by Johannes Petreius (1497–1550) (al-Farghānī 1537), a friend of Rheticus and the printer of *De revolutionibus* by Nicolaus Copernicus (1473–1543), one year before the *Sphaera* edition was printed.

This comment at the margin becomes all the more relevant when we recall that the *Sphaera* edition of 1538 also contains a fragment of al-Farghānī's work as an additional text-part. This is the Diff. 24, a chapter that discusses the rising and setting of the planets. A detailed comparison between the 1493 and 1537 editions on the one hand and this fragment on the other shows that the 1538 edition was the result of a collation between the 1537 edition and manuscripts of the same work. The striking similarity between Petreius' 1537 edition and the 1538 fragment is based on the fact that the entire punctuation as well as the lexical rendering in a more classical Latin are basically identical. However, two passages are slightly changed when the text refers to the visibility of the setting of the planets depending on the Earth's climatic zones. A comparison with five different manuscripts has shown that exactly the same passages were rendered in

9. In the preface of his 1532 commentary on Hesiod's *Works and Days*, Melanchthon indeed mentions that Hesiod's observations of rising and setting stars should be analyzed against the background of knowledge acquired through the reading of either a commentary on the *Sphaera* or Aristoteles' *De coelo* (Bretschneider and Bindseil 1843–1860, vol. 18, col. 182).

different ways and therefore testify to an incorrect transmission.[10] This implies that the 1538 fragment was edited by somebody who understood the subject matter, as it displays two content-related corrections. From the manuscripts left by Rheticus' pupil Nicolaus Gugler, moreover, we know that Rheticus had been teaching this work of al-Farghānī in the same period. Unfortunately, Gugler's notes concern only the *Differentiae* 1 to 10 and not the 24th printed in the fragment. But the notes about the Diff. 8 show Rheticus' intense focus on the exact determination of the latitudes of the climate zones (Guglero 1536–1538, 78r–79r).

3.4. The Fourth Addition

The next piece of evidence is concerned with the visual apparatus of the 1538 edition. Such an apparatus in mathematical textbooks of the time could be extremely sophisticated, containing not only rich illustrations but also diagrams or paper instruments (volvelles). The 1538 edition is special because it added a considerable number of illustrations compared to the 1531 edition, for instance, which in itself was already richer than most other *Sphaera* editions of the period. Before addressing the content-related illustrations, however, we will discuss the visual aids that were inserted to enable readers to build mathematical instruments.

The 1538 edition of the *Sphaera* introduces three new instruments through this printing technique, which spread thanks to Petrus Apianus (1495–1552) and his famous *Cosmographicus liber*, first printed in 1524 (Apian 1524). The volvelles of the 1538 *Sphere* edition are instruments for determining a) the length of days and nights, b) the sphericity of the Earth given the latitude as well as the length of the artificial days, and c) the time of events in the past (*De ortu poetico*).

While the second instrument has a clear source in Apian's work (Apian 1524, p. 24), the first and the third are more original. The third testifies to a focus on the subject *De ortu poetico* which will be discussed at length in the section dedicated to Anonymous 1543b. Concerning the second, we know that Rheticus was very familiar with Apian's works in general, as he brought some of them as a gift when he first met Copernicus in 1539 (Burmeister 1968, vol. 1, p. 39). Rheticus and Apian actually met in person in 1538 (Danielson 2006, p. 37). Rheticus, moreover, prepared a

10. We compared the fragment printed in the 1538 edition with (al-Farghānī et al. 13th–15th cent., 115v–116v (new enumeration) (BNF); al-Farghānī and al-Bitrūgi 13th cent., 26r–27v (BNF); al-Farghānī et al. 14th cent. (BNF), 10v–11r; al-Farghānī et al. 14th cent., 71v–72v (BSB); al-Farghānī and Sacrobosco 2004 14th cent., 13r–v (BNF)). The latter manuscript is the one that turns out to be closer to the wording shown in the 1538 fragment; like the 1493 and 1537 printed editions, it is based on John of Seville's translation.

Chorographie, now missing but fortunately transcribed and printed in 1876, in which he mentioned an instrument of Apian that he had personally seen (Hipler 1876, p. 148; Burmeister 1968, p. 51). Concerning the first instrument, we know that Rheticus was working in Wittenberg on mathematical instruments for use in astronomy and geography together with Erasmus Reinhold (1511–1553) and, during his stay in Prussia he built an instrument to measure the lengths of days and nights, which was then gifted (with a written description about its use) to Duke Albert of Prussia (1490–1568) in 1541. This is shown in a letter by Rheticus himself (Hipler 1876, p. 129).

3.5. The Fifth Addition

The next piece of evidence to show that Rheticus is the author of the "new" *Tractatus* contained in the 1538 *Sphaera* edition also concerns the visual apparatus but more particularly the relation between one specific illustration and the added text referring to it. In our opinion, this is the most relevant and decisive piece of evidence.

The 1538 edition shows twenty-one more illustrations than the 1531 version, while two of them have been replaced. We know that the revolution of the visual apparatus in the tradition of the *Sphaera* corpus actually began with Apian (Pantin 2020), in particular his *Cosmographicus liber* and his *Sphaera* edition of 1526 (Sacobosco and Apian 1526). One of those new illustrations was inserted to replace the older illustration typically used since the thirteenth century to represent the demonstration of the sphericity of the element water.

In particular, it shows that two observers, one on the mast and one on the hull of a ship would observe the disappearance of a castle on the shore at two different moments: The man on the mast can observe it for a longer period while the ship moves away, and the reason is the spherical shape of the element water (Fig. 2).

According to classical geocentric cosmology, the elements are ordered according to their weights: Earth, Water, Air, Fire. To explain the possibility of life outside the waters, the concept of *tumor terrae* was developed during the Middle Ages. In practice, the center of the earth's sphere was conceived to be eccentric in relation to the sphere of water, so that a portion of earth could emerge.[11]

11. The systematization of knowledge concerning the concept of *tumor terrae* was first accomplished by Petrus Abelardus in the twelfth century and was based on exegetical arguments concerned with the *Book of Genesis* (Third day). The physical explanation related to the eccentricity of the two spheres first emerged in relation to William of Moerbeke's thirteenth-century translation of Simplicius' commentary on Aristotle's *De coelo* (Nenci

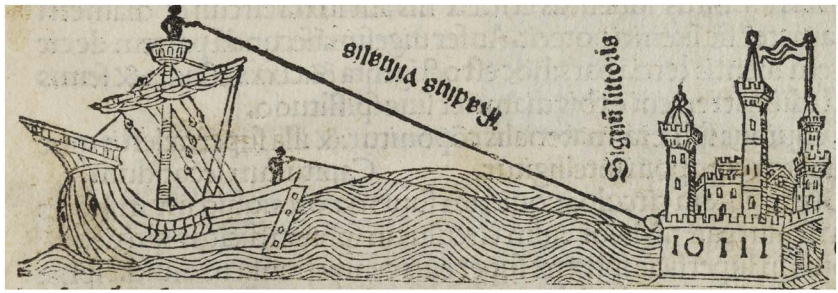


Figure 2. In the first chapter of the *Tractatus de sphaera*, Sacrobosco demonstrates the sphericity of the element water around the Earth using the empirical example of a ship leaving a shore. Medieval illustration (From Sacrobosco et al. 1490, a–III–5). Courtesy of the Library of the Max Planck Institute for the History of Science.

This is what Sacrobosco's text also describes in the first book, which contains the demonstration of the sphericity of the water element. Apian, however, repurposed the traditional argument and decided to show the entire terraqueous globe (Fig. 3).

Isabelle Pantin shows that the illustration of the terraqueous globe was a consequence of the reception of the new geographical knowledge, which was being accumulated during the journeys of exploration, and in particular of the reports concerning Amerigo Vespucci's travels (Pantin 2020). In terms of classic geocentric cosmology, this was a radical innovation as it denied validity to the Aristotelian conception of distribution of the elements. However, probably because of the then relevant authority of the textual apparatus and of Sacrobosco's original text, Apian did not change the wording of the text at all, and the illustration of the new globe remained completely uncommented.

The illustration was then reprinted in the 1531 *Sphaera* edition by Klug (as in all later Wittenberg editions) but Klug also left it uncommented. The first textual change related to the new illustration of the globe can be found in the 1538 edition, again not as a commentary but as an addition to the original text. The change is very small but relevant: Indeed, only one heading was added. While the 1531 edition titles this part in the most classical way, using the *incipit* (*Quod aqua sit rotunda*), the 1538 edition reinstated this heading as the *incipit* of the section text, adding above it: *Terram cum aqua globum constituere*.

2018). Later on, at the beginning of the fifteenth century, Paul of Burgos' formulation became particularly influential (Vogel 1995, pp. 148–9, 265–75).

Figure 3. New illustration of the demonstration of the sphericity of the water element with the terraqueous globe inserted by Apianus (Sacrobosco and Melanchthon 1568, b–5–4). Courtesy of the Library of the Max Planck Institute for the History of Science.

This is the very first textual reception of the new thinking about the distribution of water and earth on the planet's surface.[12] What counts here, however, is the comparison with a manuscript of another pupil of Rheticus, also a well-known source to his biographers by now. This manuscript contains the notes of two different classes on the *Sphaera* held by Rheticus during his second stay in Wittenberg in 1540, and in both of them the subject of the distribution of earth and water is discussed at length (Rheticus and Sacrobosco 1540, 12v–13r, 62v–64v).[13] To give an example, in the first class the *locus* is discussed as follows:

> Constituit ne aqua integram sphaeram?
>
> Non, alioqui[n] enim necesse esset ipsam universam terram contegere, quae res commodum animantibus supra terram habitacionem tolleret, sed aquae superficies iuncta superficiei terrae efficit corpus sphaericum. (Rheticus and Sacrobosco 1540, 13r)

12. Remarkably, the first two volvelles discussed above are inserted in the section of the text containing the demonstration of the sphericity of the water element.

13. The Ms. Pal. Lat. 1397 contains notes from Rheticus' classes around 1540 (fols. 1–155) and Sacrobosco's works copied in 1446, as remarked on by Ludwig Schuba, who analyzed all the quadrivium manuscripts of the Palatina collection. To date, however, no one has noted that the second part also contains a copy of Sacrobosco's *Computus ecclesiasticus* (Rheticus and Sacrobosco 1540, 156r–170r). For comparison (see Schuba 1992, pp. 164–5).

These five pieces of evidence attribute authorship to Georg Rheticus of the new edition of the *Tractatus* contained in the *Sphaera* edition of 1538. We consider him as an author in this case, same as if he had commented on the new *Sphaera* text.

4. Anonymous 1543a

After Joseph Klug's aforementioned four editions, the next edition from Wittenberg was realized by the printer Peter Seitz I (1534–1574) in 1543. It is evident that Seitz somehow received all Klug's woodblocks for this production and the new edition is almost identical, but not quite. Some changes were made and, as this edition coincides with Rheticus' second stay in Wittenberg, we shall briefly mention the changes that might be relevant to this argument.

First, al-Farghānī's fragment was now omitted. But there is an *Annotatio* in the original text whose subject refers to Prop. 22 of Regiomontanus' *Epitome*, which is still part of the edition. Probably the most relevant additions are two marginalia in Book 3 of the *Tractatus* that correct the exact degrees of the fifth and seventh climate zones, a subject that, as we have seen, is close to Rheticus' interests. One last relevant addition concerns a computational table that reports the maximal length of the natural days depending on the distance from the Arctic pole, another subject close to Rheticus and his production of instruments.

We believe, therefore, that Rheticus also worked on the 1543 edition and we can show this more convincingly in the section on Anonymous 1543b below. But first, let us consider Anonymous 1538b.

5. Anonymous 1538b

As previously mentioned, the text-part assigned to this anonymous author is a *Cisiojanus*, a series of verses to determine the non-movable liturgical feasts. Disseminated since the thirteenth century, this mnemonic-mechanical aid developed into regional forms and according to regional differences in the liturgical calendar. The *Cisiojanus* printed in the 1538 *Sphaera* edition corresponds exactly to the one that spread in the fourteenth century in Silesia, Saxony, Bohemia, and Poland (Grotefend 2007, pp. 20–1).

Because we know from Melanchthon's letter to Gasser that Rheticus came up with the idea of inserting the *Computus ecclesiasticus*, we can infer that he was also responsible for the insertion of the *Cisiojanus*. Indeed, the two works complete each other, as one concerns the movable and the other the non-movable feasts.[14] While we do not find any direct intervention in

14. As evidence that the *Computus* and the *Cisiojanus* complete each other, we found that these text-parts were each published twenty times in the corpus and always together.

the text here, we would like to infer that Rheticus acted as an editor of the entire edition, just as he did in the case of the *Tractatus de sphaera*. In our opinion, this was also the case in 1543.

6. Anonymous 1543b

The text-part assigned to this anonymous author is the aforementioned *De ortu poetico*. This text deals with the subject of the rising and setting of the stars with reference to a long series of passages from ancient literature, both Greek and Latin. As we have seen, the subject is a standard topic in the original text of Sacrobosco's *De sphaera*. This additional text-part, therefore, should be seen as an enriching commentary to that section of Sacrobosco's text. Contrary to what is often believed, *De ortu poetico* is not just a collection of passages from ancient literature that has a relation to astronomy—a collection that would provide the reader with a mnemonic aid for the subject matter on the basis of the available knowledge of the classic poems of the past. Indeed, *De ortu poetico* is a sort of tool to enable historians to exactly date events that took place in the past and for which there are testimonies that described the position of specific stars over the ecliptic in order to record the time. *De ortu* is a calendric means of investigating the past that also takes into consideration the geographical area from which the stars were observed.

We have already seen how the 1538 edition displays a marginal comment that expands the example of Sacrobosco and considers Hesiod's works. This new text-part is greatly expanded by the addition of a large variety of ancient authors, with Hesiod playing a crucial role.

Although he did not mention this text-part directly, it was, in fact, Melanchthon, who, in the same letter to Gasser, pointed to the relevance of the astronomer's capacity to date past events exactly, a skill without which history and memory would not exist and chaos would follow. Now completely forgotten, practicing *De ortu poetico* had become an increasingly relevant and sophisticated academic occupation during the early modern period and continued until the late eighteenth century.[15]

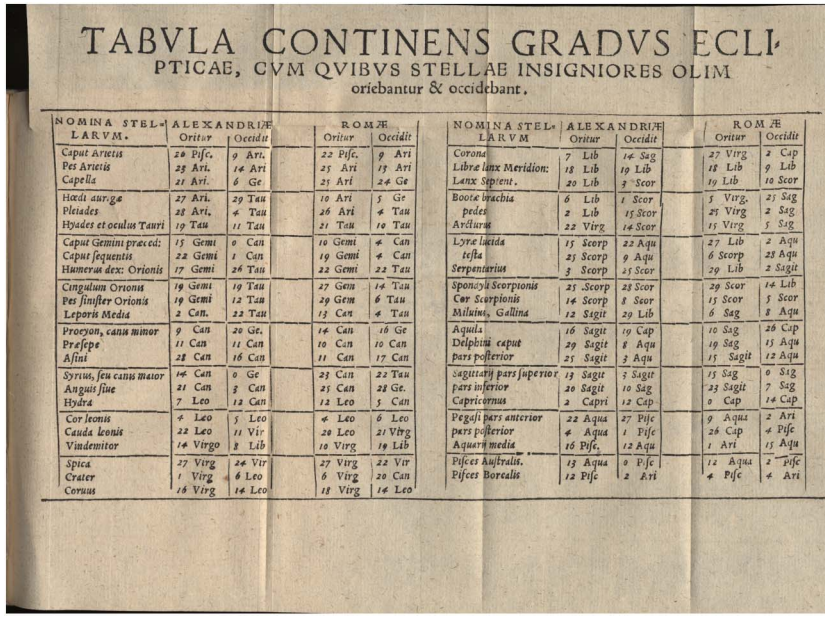
We believe that the author and editor of this text-part is Rheticus. Circumstantially we can infer this hypothesis from the fact that *De ortu poetico*

15. The subject *De ortu poetico* was discussed in Ps. Proclus *De sphaera* as well and, as such, had already been greatly expanded by Rheticus' friend Johannes Stöffler in his commentary printed a few years earlier (Stöffler and Proclus [Diadochus] 1534). Again, it was Melanchthon who also published a commentary on the results of his dating of the events mentioned in Ovid's *Fastorum libri sex* in 1539 (Bretschneider and Bindseil 1843–1860, vol. 19, cols. 473–496). Later on, the subject almost became an academic discipline by itself, as shown by the many works with the title *Exercitatio academica De ortu et occasu siderum poetica* published during the seventeenth century. A very mathematically sophisticated example from the late eighteenth-century is (Pfaff 1786).

is both a completion of Sacrobosco's *Sphaera* and an enrichment of the calendric topic in the entire edition. Secondly, it has been shown that the 1538 edition even contains a volvelle for the calculation of times of past events depending on the position of the stars over the ecliptic and the position of the observer. This convincingly testifies to Rheticus' interest in the subject.

The decisive evidence, however, comes from a different feature of this text-part. In particular, it contains two computational astronomic tables that, together with the instrument, could greatly facilitate the mathematical-astronomical workflow. These tables are 1) *Tabula continens gradus eclipticae cum quibus stellae insigniores olim oriebantur et occidebant* and 2) *Tabula continens ingressum solis in XII. signa Zodiaci. Verum item locum solis, ad singolos dies anni, veterum poetarum temporibus accomodata* (Figs. 4 and 5).

The first table lists twenty-four stars and the degrees of their rising and setting over the ecliptic as observable by the ancient authors in Rome and Alexandria. The second shows on which day of each month the Sun would

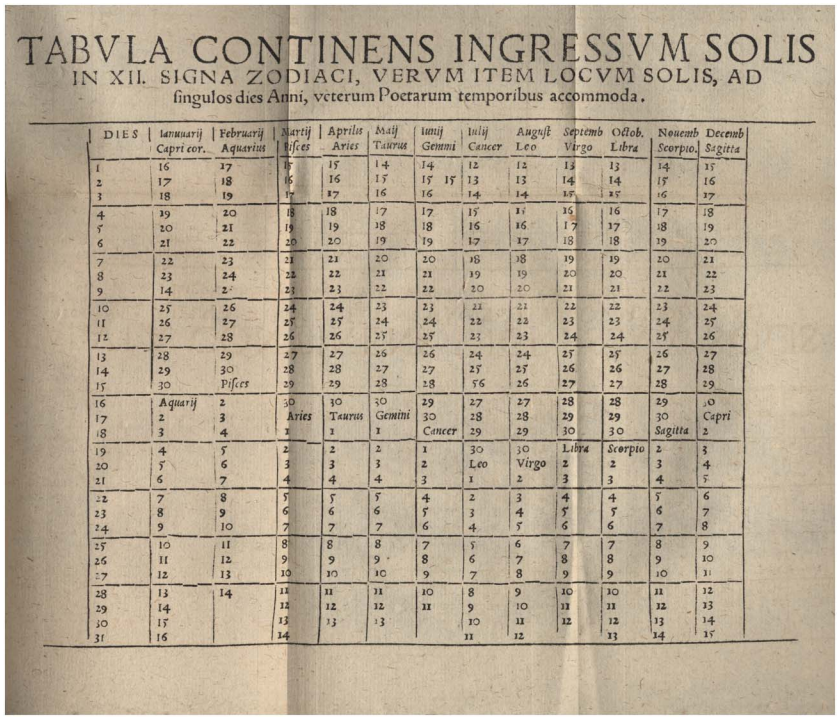


TABVLA CONTINENS GRADVS ECLI-
PTICAE, CVM QVIBVS STELLAE INSIGNIORES OLIM
oriebantur & occidebant.

NOMINA STEL-LARVM.	ALEXANDRIÆ Oritur	ALEXANDRIÆ Occidit	ROMÆ Oritur	ROMÆ Occidit
Caput Arietis	20 Pisc.	9 Ari.	22 Pisc.	9 Ari
Pes Arietis	25 Ari.	14 Ari	25 Ari	13 Ari
Capella	21 Ari.	6 Ge	25 Ari	24 Ge
Hœdi aurigæ	27 Ari.	29 Tau	10 Ari	5 Ge
Pleiades	28 Ari.	4 Tau	26 Ari	4 Tau
Hyades et oculus Tauri	19 Tau	11 Tau	21 Tau	10 Tau
Caput Gemini præced:	15 Gemi	0 Can	10 Gemi	4 Can
Caput sequentis	22 Gemi	1 Can	19 Gemi	4 Can
Humerus dex: Orionis	17 Gemi	26 Tau	22 Gemi	22 Tau
Cingulum Orionis	19 Gemi	19 Tau	27 Gem	14 Tau
Pes sinister Orionis	19 Gemi	12 Tau	29 Gem	6 Tau
Leporis Media	2 Can.	22 Tau	13 Can	4 Tau
Procyon, canis minor	9 Can	20 Ge.	14 Can	16 Ge
Præsepe	11 Can	11 Can	10 Can	10 Can
Asini	28 Can	16 Can	11 Can	17 Can
Syrius, seu canis maior	14 Can	0 Ge	23 Can	22 Tau
Anguis siue	21 Can	8 Can	25 Can	28 Ge.
Hydra	7 Leo	12 Can	12 Leo	5 Can
Cor leonis	4 Leo	5 Leo	4 Leo	6 Leo
Cauda leonis	22 Leo	11 Vir	20 Leo	21 Virg
Vindemitor	14 Virgo	8 Lib	10 Virg	19 Lib
Spica	27 Virg	24 Vir	27 Virg	22 Vir
Crater	1 Virg	6 Leo	6 Virg	20 Can
Corvus	16 Virg	14 Leo	18 Virg	14 Leo

NOMINA STEL-LARVM	ALEXANDRIÆ Oritur	ALEXANDRIÆ Occidit	ROMÆ Oritur	ROMÆ Occidit
Corona	7 Lib	14 Sag	27 Virg	2 Cap
Libræ lanx Meridion:	18 Lib	19 Lib	18 Lib	9 Lib
Lanx Septent.	20 Lib	3 Scor	19 Lib	10 Scor
Bootæ brachia	6 Lib	1 Scor	5 Virg.	23 Sag
pedes	2 Lib	15 Scor	25 Virg	2 Sag
Arcturus	22 Virg	14 Scor	15 Virg	5 Sag
Lyræ lucida	15 Scorp	22 Aqu	27 Lib	2 Aqu
testa	25 Scorp	9 Aqu	6 Scorp	28 Aqu
Serpentarius	3 Scorp	25 Scor	29 Lib	2 Sagit
Sponcyli Scorpionis	25 Scorp	28 Scor	29 Scor	14 Lib
Cor Scorpionis	14 Scorp	8 Scor	15 Scor	5 Scor
Miluus, Gallina	12 Sagit	29 Lib	6 Sag	8 Aqu
Aquila	16 Sagit	19 Cap	10 Sag	26 Cap
Delphini caput	29 Sagit	8 Aqu	19 Sag	15 Aqu
pars posterior	25 Sagit	3 Aqu	15 Sagit	12 Aqu
Sagittarij pars superior	13 Sagit	5 Sagit	15 Sag	0 Sag
pars inferior	20 Sagit	10 Sag	23 Sagit	7 Sag
Capricornus	2 Capri	12 Cap	0 Cap	14 Cap
Pegasi pars anterior	22 Aqua	27 Pisc	9 Aqua	2 Ari
pars posterior	4 Aqua	1 Pisc	26 Cap	4 Pisc
Aquarii media	16 Pisc.	12 Aqu	1 Ari	15 Aqu
Pisces Australis.	13 Aqua	0 Pisc	12 Aqua	2 Pisc
Pisces Borealis	12 Pisc	2 Ari	4 Pisc	4 Ari

Figure 4. *Tabula continens gradus eclipticae cum quibus stellae insigniores olim oriebantur et occidebant* (From Sacrobosco and Melanchthon 1568, foldout attached). Courtesy of the Library of the Max Planck Institute for the History of Science.



TABVLA CONTINENS INGRESSVM SOLIS
IN XII. SIGNA ZODIACI, VERVM ITEM LOCVM SOLIS, AD
singulos dies Anni, veterum Poetarum temporibus accommoda.

DIES	Ianuarij Capri cor.	Februarij Aquarius	Martij Pisces	Aprilis Aries	Maij Taurus	Iunij Gemini	Iulij Cancer	Augusti Leo	Septemb Virgo	Octob. Libra	Nouemb Scorpio.	Decemb Sagitta
1	16	17	15	15	14	14	12	12	13	13	14	15
2	17	18	16	16	15	15 15	13	13	14	14	15	16
3	18	19	17	17	16	16	14	14	15	15	16	17
4	19	20	18	18	17	17	15	15	16	16	17	18
5	20	21	19	19	18	18	16	16	17	17	18	19
6	21	22	20	20	19	19	17	17	18	18	19	20
7	22	23	21	21	20	20	18	18	19	19	20	21
8	23	24	22	22	21	21	19	19	20	20	21	22
9	14	25	23	23	22	22	20	20	21	21	22	23
10	25	26	24	24	23	23	21	21	22	22	23	24
11	26	27	25	25	24	24	22	22	23	23	24	25
12	27	28	26	26	25	25	23	23	24	24	25	26
13	28	29	27	27	26	26	24	24	25	25	26	27
14	29	30	28	28	27	27	25	25	26	26	27	28
15	30	Pisces	29	29	28	28	56	26	27	27	28	29
16	Aquarij	2	30	30	30	Gemini	27	27	28	28	29	30
17	2	3	Aries	Taurus	Gemini	30	28	28	29	29	30	Capri
18	3	4	1	1	1	Cancer	29	29	30	30	Sagitta	2
19	4	5	2	2	2	1	30	30	Libra	Scorpio	2	3
20	5	6	3	3	3	2	Leo	Virgo	2	2	3	4
21	6	7	4	4	4	3	1	2	3	3	4	5
22	7	8	5	5	5	4	2	3	4	4	5	6
23	8	9	6	6	6	5	3	4	5	5	6	7
24	9	10	7	7	7	6	4	5	6	6	7	8
25	10	11	8	8	8	7	5	6	7	7	8	9
26	11	12	9	9	9	8	6	7	8	8	9	10
27	12	13	10	10	10	9	7	8	9	9	10	11
28	13	14	11	11	11	10	8	9	10	10	11	12
29	14		12	12	12	11	9	10	11	11	12	13
30	15		13	13	13		10	11	12	12	13	14
31	16		14				11	12		13	14	15

Figure 5. *Tabula continens ingressum solis in XII. signa Zodiaci. Verum item locum solis, ad singolos dies anni, veterum poetarum temporibus accomodata* (From Sacrobosco and Melanchthon 1568, foldout attached). Courtesy of the Library of the Max Planck Institute for the History of Science.

enter the constellations of the twelve signs but "adjusted for what concerns the time of the ancient authors."

The proof that Rheticus is the author of these tables and, in our opinion of the whole text-part, comes from an appendix entitled *De generibus ortuum*, which Rheticus added in his class on Ps. Proclus' *Sphaera*, now attributed to Geminus of Rhodes (first century BCE) (Biank 2019). Once again, the available source is the manuscript that preserves Gugler's notes from Rheticus' classes between 1536 and 1538. Here, Rheticus mentions the complex workflow that students should accomplish in order to determine the time of the rising and setting of the stars observed by the ancient authors by starting from the Alfonsine tables and the position of Wittenberg and explicitly says that he has produced these tables for them to obviate this effort (Guglero 1536–1538, 52v–53r). The appendix, moreover, can be seen

as a previous draft of the entire *De ortu poetico*. Among the examples discussed in class we now find the star Arcturus and the mention of Hesiod as additional evidence that Rheticus is also the author of the commentary in the margin of the *Tractatus* of the 1538 *Sphaera* edition.

Generally speaking, the subject of *De ortu poetico* had already been discussed by a great number of scientists, including those in the Wittenberg circle, and therefore we surmise that the text published in 1543 was edited rather than authored by Rheticus. But the tables and the volvelle are, in our opinion, to be assigned to him as an author.

7. Rheticus in the Network of Authors

For the reasons listed in the previous sections, we conclude that Rheticus was the overall editor and designer of the 1538 and 1543 editions of *De sphaera* printed in Wittenberg by Klug and Seitz I respectively, and was therefore responsible for the presence or absence of the specific text-parts which constitute such editions. In particular, we assign Rheticus the role of editor in relation to al-Farghānī's fragment, the *Computus* and the *Cisiojanus*, while he is considered as the author of the 1538 and 1543

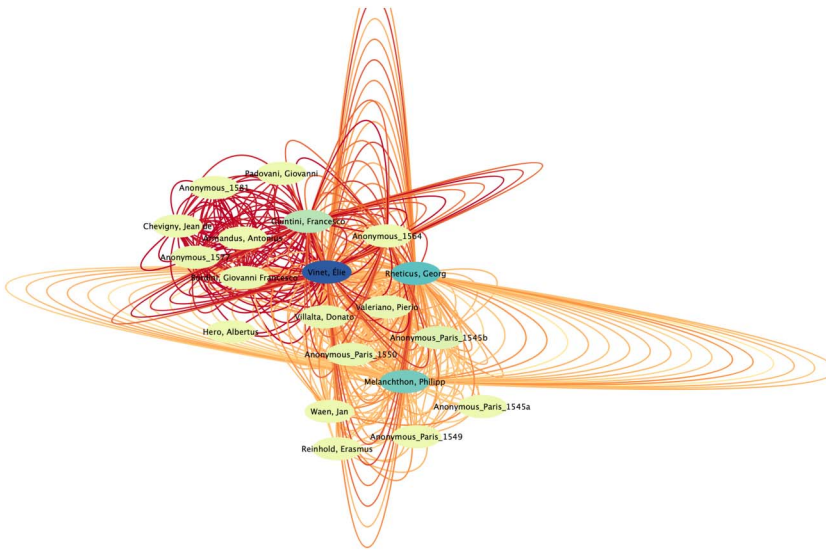


Figure 6. Social network visualization of the text-part authors. Authorship of text-parts previously assigned to Anonymous 1538a, 1543a, and 1543b is now assigned to Georg Rheticus. The network is not oriented. Betweenness centrality is colored.

revisions on Sacrobosco's original text as well as of *De ortu poetico*, and especially its tables.

If we now consider only the text-parts he authored and assign the name and the life dates of Rheticus to them (Anonymous 1538a, 1543a and 1543b) and only then go back to our network, the situation appears quite different. In this case, the component consists of twenty nodes, namely authors. Rheticus ranks in second position after Vinet for both betweenness and closeness centrality while he scores highest for degree (132 connections) (Fig. 6).

8. The Impact of Rheticus in Europe

As mentioned, this network is based on the text-parts and their recurrences, while such text-parts have been identified if and only if the analyzed printed edition clearly shows a beginning and an end of the text-part at hand. However, this does not exclude the possibility that the same content is present in other editions, eventually printed in a *continuum* as a part of a commentary. Only by considering all cases, even beyond those used for the network analysis, are we finally able to measure the impact of Rheticus in the frame of geocentric cosmology education in Europe.

To measure the impact, we count the recurrences of the text-parts Rheticus both authored and edited, while keeping them distinct: the *Tractatus*, both versions of 1538 and 1543 (23 occurrences), *De ortu poetico* (67 occurrences), the *Cisiojanus* (20 occurrences), the *Computus* (20 occurrences), and al-Farghānī's fragment (50 occurrences).

The spread of *De ortu poetico* across the *Sphaera* corpus is more significant than it might seem at first glance. Here we deal with three kinds of recurrences: a) reissues of the 1543 text-part, by preserving a nearly identical layout, including the tables as folded leaves (46 instances in our corpus); b) occurrences of *De ortu poetico* within a different and/or longer text-part, identified by the presence of the table "adjusted for what concerns the time of the ancient authors" (Fig. 5) (100 instances);[16] and c) different versions

16. As we were able to attribute the authorship of the tables (Figs. 5, 6) to Rheticus, we supported our research by searching for those tables only. In total we found 92 occurrences of the table "adjusted for what concerns the time of the ancient authors" (Fig. 5). 46 of them were overlapping with the re-occurrences of Rheticus' text-part *De prtu poetico*, as described in point a). Further 46 pointed us to the passages of the corresponding editions where the same subject was discussed. We consider the presence of Rheticus' table to assert an influence of his works on those 46 treatises, where the table was found. To identify the table, a new theoretical machine-learning approach to identify digits in numerical tables by means of bigrams (Eberle et al., 2020) was developed in the frame of the overarching project BIFOLD, to which the *Sphaera* project also belongs. Then the same group developed a deep convolutional network able to identify equal or similar tables. The new algorithm will soon be published.

of the text-part *De ortu poetico*, but clearly influenced by Rheticus' original text (8 instances).

The third case is represented by eight editions of Sebastian Dietrich's (1521–1574) *Novae quaestiones sphaerae* (Dietrich 1564, 1567, 1570, 1573, 1578, 1583, 1591, 1605).[17] Dietrich based his work on another Wittenberg textbook: Kaspar Peucer's (1525–1602) *Elementa doctrinae de circulis coelestibus, et primo motu*, first published in 1551 (Peucer 1551) and then re-published another eight times up until 1601. Dietrich studied in Wittenberg between 1538 and 1544, and one year later he began teaching in the same university. Peucer arrived a few years later than Dietrich, in 1543, but quickly became one of the three most important pupils of Melanchthon itself (Westman 1975). He took over the teaching activity in 1550 and became professor in 1553, replacing Erasmus Reinhold.

Peucer's text is not a direct commentary on Sacrobosco's text but includes and expands Rheticus *De ortu poetico*, as it is easily recognizable by looking at the passages of ancient literature that are analyzed as examples in both texts. Among them, the most significant common denominator is represented by the detailed study of Hesiod's second book of *Works and Days*, a work ignored in the original tract of Sacrobosco.[18] Peucer's text, moreover, also contains Rheticus' tables. Dietrich finally transformed Peucer's text into a book structured as a series of questions and answers, leaving the actual content fully unchanged. Concerning the *Sphaera*, this genre, was specifically conceived as a student aid, possibly to prepare for an examination.

But Dietrich's work was not the first transformation of the text of Sacrobosco (and Rheticus' additions) into a book structured in such a way. A work belonging to this genre had already appeared in 1549. This work—*Quaestiones novae, in libellum de Sphaera Iohannis de Sacro Busto*—was authored by Hartmann Beyer (1516–1577). He began as a student together with Rheticus and then became his pupil. He started his teaching career as a private tutor in Wittenberg and later also received a chair at the university there (Burmeister 2015, 103–04). This work, which has been classified as a great transmitter (Zamani et al. 2020), was originally printed in Frankfurt (three times in 1549!) and then a further sixteen times

17. For each edition we have controlled only one exemplar. In three cases, we could identify the other tables (Fig. 6). In other cases, the electronic copies we had at our disposal clearly show the presence of tables that, however, have not been unfolded and scanned. This example testifies to the necessity for a still missing standard and professional procedure for the electronic reproduction of historical sources.

18. For an example of the discussion concerned with Hesiod's verses 382–386, compare (Sacrobosco and Melanchthon 1543, H–2; Peucer 1551, M–1; Dietrich 1564, p. 208).

altogether in Wittenberg, Frankfurt am Main, and Paris by the great international publisher and bookseller Guillaume Cavellat.[19] Beyer's work not only contains Rheticus' tables but also explicitly and repeatedly mentions that the subject is developed by considering the position of Wittenberg to begin the calculations.[20]

From a geographical point of view those text-parts now assigned to Rheticus traveled from Wittenberg to Paris, Antwerp, Venice, and Lyon, via Cologne and Frankfurt—namely, to all major European centers of book printing in the early modern era. Looking at the temporal distribution, Rheticus' work impacted the textbook tradition represented by our corpus in the extended timeframe from 1538 to 1629. The temporal distribution of the spread of Rheticus' text part is in line with the results calculated in previous studies for the Wittenberg editions in general. It reached a high distribution after 1543 and the peak between 1550 and 1560, while the decline in circulation was very slow in time, allowing such texts to execute a long-term influence well after the turn of the century (Fig. 7).

The plot shows the diffusion of Rheticus' text-parts—as author (blue) and as editor (red)—in comparison with other text-parts that fundamentally shaped the astronomical and cosmological knowledge of the late medieval and early modern periods: the *Theoricae planetarum* and Regiomontanus' *Epitome*.

Concerning Regiomontanus' *Epitome*, the editions of the corpus contain only the aforementioned fragment that corresponds to Prop. XXII, Book 3. The comparison is especially important because this text-part is not only the most frequently republished one but also the part that has been identified as the text-part with the highest value as a builder of semantic communities (Zamani et al. 2020).

Under the heading *Theoricae planetarum,* several works circulated in the early modern period with the goal of describing the orbits of the planets as well as the method for calculating their positions. The *theoricae* were read in class after the *Sphaera* class by all those students who were interested in mathematical education, and represented the first step toward mathematical astronomy. Their influence on the early modern knowledge on astronomy cannot be underestimated (Pedersen 1962, 1981; Aiton 1987; Pantin 2012; Malpangotto 2016). Leaving aside the circulation of these works in general and considering only those instances in which these works were printed and published together with Sacrobosco's *Sphaera*, we find three

19. For the activity of Guillaume Cavellat in the frame of the *Sphaera* corpus, see https://hdl.handle.net/21.11103/sphaera.100726 (accessed March 7, 2020). For his activity as a publisher (see Pantin 1998, 2022).

20. As an example, see Sacrobosco and Beyer (1550, 57r, 59v).

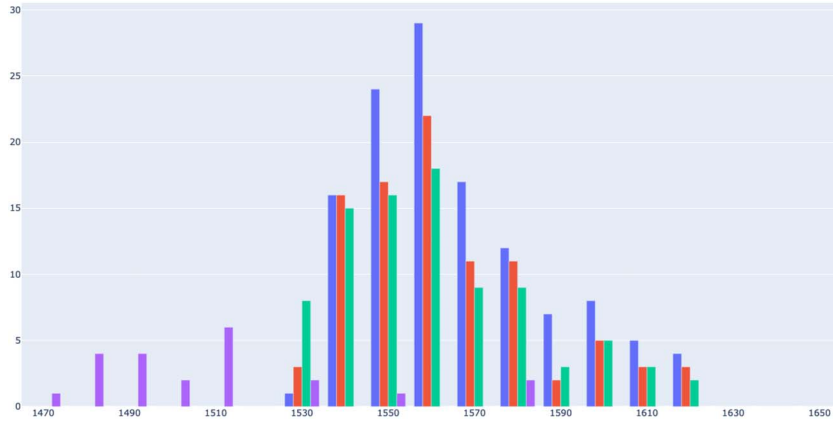


Figure 7. Temporal distribution of the diffusion of the text-parts assigned to Rheticus as author (blue) and as editor (red) in comparison to the Prop. XXII, Book 3 of the *Epitome* of Regiomontanus (green) and to the *Theoricae planetarum* of Nur ad-Din al-Bitruji, Gerard of Cremona, and Georg Peuerbach, including various commentaries on the latter (purple).

texts: the *theoricae* of Nur ad-Din al-Bitruji (d. 1204), those of Gerard of Cremona, and finally the *theoricae novae* of Georg von Peuerbach. The first appears only once, the second five times, and the third ten times in its original form, six times commented by Francesco Capuano (1450–1490), twice by Francesco Giuntini, and then once respectively by Pedro Nuñes, Silvestro Mazzolini (1456–1527) and Peter Apianus. In total there are eight authors, two of whom are from previous centuries.

In our opinion, these comparative figures enable precise estimation of the kind of impact that Rheticus, through his work as author and editor, exerted in Europe during the early modern period, an aspect that was fully neglected by Rheticus biographers and even by those who already suspected his intervention in some of the text-parts discussed above. These figures, in conclusion, allow us to consider him as the "hidden *praeceptor*" not just of Germany but of Europe, and this within the conceptual frame of geocentric cosmology.

Contributions

- Analysis of historical sources: B. Federau, O. Nicolaeva, M. Valleriani
- Data preparation: B. Federau, O. Nicolaeva

- Data Revision: B. Federau, M. Valleriani
- Network analysis: B. Federau
- Scripts and Visualization: B. Federau, O. Nicolaeva
- Results discussion: B. Federau, O. Nicolaeva, M. Valleriani
- Writing: M. Valleriani

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