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Copernicus, his Latin style and comments to *Commentariolus*

Abstract

A methodology of historical or higher criticism and of stylometry/stylochronometry known from Biblical and literary studies is applied to the examination of Nicolaus Copernicus's writings. In particular, his early work *Commentariolus* is compared at the level of the Latin language with his later ones (*Meditata*, *Letter against Werner* and *De revolutionibus*) as well as the texts of some other authors. A number of striking stylistic dissimilarities between these works have been identified and interpreted in the light of stylometry/stylochronometry, historical criticism and

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the history of Copernican research. The conducted research allowed to draw some plausible conclusions about the *Sitz im Leben* (historical context), the dating of *Commentariolus* and related matters.

Keywords: *Copernicus, copernicology, Copernican studies, metacopernicology, Commentariolus, Meditata, Letter against Werner, De revolutionibus, historical criticism, Latin stylistic analysis, stylometry, stylochronometry.*

Kopernik, styl jego łaciny i komentarze do *Commentariolus*

Abstrakt

Metodologia krytyki historycznej albo wyższej krytyki i stylometrii/stylochronometrii, znana z bibliologii i literaturoznawstwa, jest zastosowana do badania pism Mikołaja Kopernika. W szczególności jego wczesne dzieło *Commentariolus* porównuje się na poziomie języka łacińskiego z późniejszymi: jego własnymi (*Meditata*, *List przeciwko Wernerowi* i *De revolutionibus*) oraz innych autorów. Zidentyfikowano w tych pracach szereg uderzających różnic stylistycznych, które zinterpretowano w świetle stylometrii/stylochronometrii, krytyki historycznej oraz historii badań Kopernikowskich. Przeprowadzone badanie pozwoliło na wyciągnięcie prawdopodobnych wniosków na temat „Sitz im Leben" (kontekstu historycznego) i datowania *Commentariolus*.

Słowa kluczowe: *Kopernik, kopernikologia, badania kopernikańskie, metakopernikologia, Commentariolus, Meditata, List przeciwko Wernerowi, De revolutionibus, krytycyzm historyczny, Latin stylistic analysis, stylometria, stylochronometria.*

1. Introduction

The book *Różne oblicza Mikołaja Kopernika. Spotkania z historią interpretacji* (*Different faces of Nicholas Copernicus. Meetings with a history of interpretations*) by Michał Kokowski is an attempt to establish what might properly be called the science of metacopernicology – the research of all research ever produced on Nicolaus Copernicus and

his writings made from the perspective of history of ideas[1]. "The gallery of Copernicus portraits" meticulously lists various intellectual portraits of this man, i.e.various interpretations ever made of him and his works by all kinds of historians, philosophers, other scientists and artists (painters and poets). The conclusion is straightforward: we are far from a wide reflexive equilibrium on the basis of this set of portraits. It is *a fortiori* barely possible to find a single point for consensus. Lamenting the situation, M. Kokowski concludes that it is necessary to look for new ways (e.g., interdisciplinary studies) to approach the problem. From this standpoint the following key issues are relevant for this paper:

- Since historians do not access historical facts directly, when writing about Copernicus, we create *our interpretations* of the bygone reality based on the preserved sources and the research method adopted; therefore, we must clearly mention these sources and methods applied in our works – *this is both an epistemological and a methodological requirement*.
- When creating historical interpretations, including the Copernican studies, we must be *critical*: be consistent towards the historical facts, but at the same time be free to use the interpretative tools if that is fruitful for the research – *this is both an epistemological and a methodological requirement*.
- In particular in the Copernican studies we must avoid the hagiographic approach, which is manifested both a) in creating an uncritical description of Copernicus's life, his achievements and their reception in the society of the past and today (e.g. "he was a genius *without limitations*", "he was a talented painter and a talented poet" etc.), and b) in creating an impression that all our

[1] See Kokowski 2009a. The book continues the tradition of *regesta Copernicana*. However, in a sharp contrast to the earlier works of this kind it is not about the facts from Copernicus's biography, but about the different interpretations of him and his achievements. Before the book was published, its manuscript was reviewed by the late professor Marian Biskup, the author of *Regesta Copernicana* (1973), and the late professor Bronisław Średniawa (a historian of physics), and received their very positive opinions. Then in 2010 for this book its author became a laureate of the Nicholas Copernicus Scientific Award of the Kraków City Foundation (the Award is given every five years by the Polish Academy of Arts and Sciences).

Metacopernicology stems from the idea of *regesta Copernicana*, Lovejoy's history of ideas, meta-history of science and methodology of history of science – cf. Kokowski 2001, pp. 5–9, 232–237; 2006b.

interpretations describe *true facts* (e.g. "Copernicus believes, thinks that ...", "Copernicus makes this and that")[2] – *this is both an epistemological and a methodological requirement*.

- All historical interpretations have their histories and the Copernican studies are not exceptions to the rule. We must remember what different researchers previously said in these studies and cite them properly – *this is both an ethical and a professional requirement*.

Consequently, we would like to pay tribute to Ludwik Antoni and Aleksander Birkenmajer, whose scientific vision was actively followed in the present paper. It was in A. Birkenmajer's speech "Zakres filologicznych prac typu analityczno-komentatorskiego" [The scope of philological works of the analytical and commentary type] delivered at the General Assembly of the Polish Philological Society in Toruń in 1952 and published for the first time after his death in 1968 that he pointed to three elements, fruitful for future research: examination of the autograph, improved translations into Polish and what he called "analytical studies"[3]. He primarily understood the latter as locating Latin sources

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[2] In the 21st century, the hagiographic strategy was used e.g. a) in the search for the tomb of Copernicus, b) in support of its discovery, c) in a campaign of this discovery, promoted in the media (not only the broad public opinion, but also American specialists in the Copernican research were deceived by this campaign). For a detailed description of these issues, see Kokowski 2007 (in Polish); (ed.) 2015a; 2015b; 2015c; 2020 (in Polish); Walanus, Kokowski 2015.

[3] Aleksander Birkenmajer's program grew out of the research on the biography of Nicolaus Copernicus, his scientific achievements and the reception of his works, which was organized by the Akademia Umiejętności w Krakowie (Academy of Arts and Sciences in Kraków; from 1918, Polska Akademia Umiejętności – the Polish Academy of Arts and Sciences) from the 1890s to 1929. As part of this research, the team, which included Ludwik Antoni Birkenmajer, Aleksander Czuczyński, Edward Barwiński, Jerzy Łoś and Aleksander Birkenmajer (son of Ludwik Antoni), conducted searches in Polish and foreign libraries and archives (in Austria, the Czech Republic, Germany, Sweden, Finland etc.). Ludwik Antoni Birkenmajer, who is one of the most prominent figures in the history of copernicology, consequently published a series of ground-breaking publications – see L.A. Birkenmajer 1892–1893; 1900/1976 (the English translation of his *opus magnum* is available thanks to Owen Gingerich and Jerzy Dobrzycki); 1923; 1924; L.A. Birkenmajer, Collijn 1909; Barwiński, L.A. Birkenmajer, Łoś 1914; L.A. Birkenmajer, A. Birkenmajer 1917; Kokowski (ed.) 2002; 2009a; 2012a; Goddu 2018.

Later on, Aleksander Birkenmajer's program resulted in the Warsaw edition of Copernicus's collected works – see Copernicus / Kopernik 1953; 1972; 1976; 1978; 1985; 1986; 1987; 1992; 2007.

of Copernican terminology and hidden allusions in the text. Indeed, since the genuinely new documentary evidence is becoming increasingly difficult to find, searching for more subtle clues seems to be the only way forward. When developing this influential line of thought, it can be constructively suggested that a deeper investigation into Copernicus's writings could be done by adopting the well-known (from Biblical and literary studies) methodology of historical (higher) criticism as well as the modern science of stylometry. After all, the aim of this methodology is to understand "the world behind the text,"[4] which is exactly *mutatis mutandis* what copernicology is after. The present paper focuses on the analysis of Copernicus's use of Latin language – i.e. his writing style.

2. Preliminaries: a portrait 'Copernicus as a Latin writer'

There has never been many researchers that shared the vision of Ludwik Antoni and Aleksander Birkenmajer. The following list contains the most prominent publications we could find:

- In 1873, on the occasion of the 400-year anniversary of Copernicus's birthday, *Sumptibus Societatis Copernicanae* in Toruń financed the publication of a Latin edition of Copernicus's works[5]. The editors expressed some ideas on Copernicus's style in a short *prolegomena* (pp. XX–XXIII). In a passage, important for further discussion, they mentioned that Copernicus did not follow the so-called Ciceronian style[6]. Besides, being polite in general, they still pointed out to some possible solecisms,[7] e.g. using "*quod*" instead of "accusative-cum-infinitive", combining "*facit*" with infinitive and so on.[8]

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[4] R.N. Soulen, R.K. Soulen 2001, p. 78.

[5] Including "*Narratio prima*" of Rheticus, see Copernicus, Rheticus 1873.

[6] *Op. cit.* page XXI: *Quominus Copernicus stilo, quem Ciceronianum dicunt, uteretur in opere suo, ipsa res impedivit, quae in theorematis demonstrandis formulas quasdam postulavit, quibus neglectis sententia auctoris multis eidem studio deditis haud perspicua fuisset.*

[7] *Op. cit.* page XXI: *Alios soloecismos non mathematico, sed viro docto illius aetatis condonabis, qui, cum aliud ac linguae studium amplexus esset, non potuit aliter scribere, atque usu et doctrina communi didicerat.*

[8] *Op. cit.* page XXI: I*ndicativo modo utitur in indirectis, quas dicunt, quaestionibus, numquam vero perperam in propositionibus a cum vel ut pendentibus; coniunctivum sine causa quod et dum particulis subiungit; temporum, quam dicunt, consecutionem negligit.*

- It was these quite innocent remarks that brought to life a sharp rebuttal in the work of Alfred Brandowski[9]. Essentially, he admitted that the style of Copernicus was not purely Ciceronian. However, he made a valid point that it was not "barbarian" (i.e. scholastic) either. He placed Copernicus into a special third group of so-called "moderate supporters of the Renaissance[10]". They were supposed to be free from extremities of both Ciceronians,who loved paganism too much, and scholastics, who loved Medieval Latin too much. The paper contains further lists of Latin citations that were supposed to prove that the above-mentioned doubtful Latin constructions of Copernicus were widely used by different authors and thus could not be solecisms after all.
- Perhaps the most substantial study of Copernicus's Latin to date – also distinguished as such by A. Birkenmajer – was conducted by Jerzy Kowalski.[11] He analyzed in depth not only *De revolutionibus* but also Theophylactus Simocatta's verses,[12] some of Copernicus's letters and even the pseudo-epigraphic[13] *Septem Sidera*. His conclusions confirmed that Copernicus's style could not be called Ciceronian. Copernicus also did not appear to him as being well-read in the classical literature. In general, Copernicus preferred clear and simple Latin. However, some of his passages are truly elegant, contain original metaphors and puns. So, he could, if he wished, write beautiful Latin. Jerzy Kowalski listed some of his letters as examples of such texts, e.g. the preface to Theophylactus Simocatta's verses, and the preface and

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[9] See Brandowski 1876.

[10] In Polish: "Umiarkowani zwolennicy renesansu".

[11] See Kowalski 1924.

[12] See Copernicus 1953.

[13] Jan Brożek (1585–1652), the first researcher of the life and achievements of Copernicus, in 1619 and 1629 mistakenly ascribed the authorship of *Septem Sidera* to Copernicus. This error was repeated by some historians of science, including Franz Hipler (1873, pp. 152–153), Leopold Prowe (1883, vol. II, pp. 372–375) and L.A. Birkenmajer (1923, pp. 86–88) and was corrected only by the philologist Jerzy Krókowski, who discovered that *Septem Sidera* is "typical of *parodia Horatiana*, which was a popular poetic style in the 17th century"– see Krókowski 1926; Wałęga 1973; Witkowski 1975; Mikołajczyk, Mróz 2010; Mikołajczyk 2010; Milewska-Waźbińska 2016, especially p. 300.

introduction to *De Revolutionibus*. In other words, Copernicus attuned his style to the content.

- More recent texts on the subject include the introduction to Theophylactus Simocatta's verses[14], the above-mentioned speech of A. Birkenmajer[15] and some other papers[16]. These can be seen as a continuation in the tradition of treating the Copernican Latin corpus as a whole.

3. General approach – comparison of texts

In contrast to the aforementioned research, our approach has been to focus on the comparison of several of Copernicus's works with each other. Luckily, we are in possession of several of his texts spread over the course of 40 years (ca. 1501–1543). Unfortunately, most of them – the only exception being the *magnum opus* – are quite short. The hope was that analyzing them would allow us to add further details to the image of Copernicus. The certainty is that their comparison would assist us in building a dynamic model of his development as a scientific and psychological character.

Paraphrasing Alfred North Whitehead[17], it can be claimed that the whole history of modern cosmology can be seen as a series of footnotes or comments to the *Commentariolus*[18] – the first ever clear formulation of heliocentric (heliostatic, to be more exact) theory.[19] Incidentally, it is also the earliest – discounting the translation of Theophylactus Simocatta's verses[20] as non-scientific – scientific text of Copernicus known to us. Accordingly, it is the investigation of *Commentariolus* against the later writings of Copernicus that appears *prima facie* the most promising. The texts relevant for comparison purposes should be close

[14] See Gansiniec 1953.

[15] See A. Birkenmajer 1968.

[16] See Czartoryski 1978; Rosińska 2001; Bieńkowski 2008.

[17] "The safest general characterization of the European philosophical tradition is that it consists in a series of footnotes to Plato" (Whitehead 1929/1985).

[18] About *Commentariolus*'s provenance, title, dating and its recipients see Appendix 1.

[19] It should be distinguished from the heliocentric speculations of the Pythagoreans and Aristarchus of Samos

[20] See Copernicus 1953 (for the Latin text); Rosen 1985a (for the English translation).

to it – ideally having a similar topic, literary genre and/or date. As such, we selected the following for comparative purposes:[21]

1. A collated text of *Commentariolus* (1501–1514, probably ca. 1508–1514[22]).
2. The so-called *Letter against Werner* (1524) as his astronomical work in a (presumably) similar genre of letter to a friend.
3. *De revolutionibus*[23] (presumably written between ca. 1515 and 1541 or even June 1542 ("Dedication letter to Pope Paul III")[24], first printed before 21st of March 1543) as covering a similar topic to Commentariolus. In this article, we focus on the Latin style of Copernicus, our research has been therefore limited to the first book only (as the most non-mathematical) and included the *Praefatio*.[25]

Moreover, we will also use some auxiliary economic texts:

1. The monetary reform treatise *Meditata* (1517) as the second in chronology of Copernicus substantial texts.
2. *Monetae Cudendae Ratio* of Nicolaus Copernicus (1522, final edition 1528).

4. *Sigla*

In order not to repeat the titles or key terms in the article many times, let us introduce some abbreviations.

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[21] For the stylometric investigation we used the transcribed texts found at online resources such as https://la.wikisource.org/ and http://copernicus.torun.pl/en/archives. Even though we did our best to make sure they are identical with the published works, some minor discrepancies might be possible. These differences in no case undermine the obtained results since they cannot be statistically significant.

[22] See Appendix 1.3. However, consider the alternative dating suggested in section 10 below.

[23] Based on the view of Jan Brożek and Tiedemann Giese, Polkowski (1873, pp. 270–271), L.A. Birkenmajer (1900, pp. 645, 649, 656; 1920, p. 3); Gansiniec (1958) and A. Birkenmajer 1976 (in: Copernicus 1976, pp. 328–329) argued that the words "*orbium coelestis"* in the title *De revolutionibus orbium coelestis* were added by the publishers of the works of Copernicus in Nürnberg and therefore it is preferrable to use *De revolutionibus*.

[24] *De revolutionibus* was dated by analyzing the autograph content and its paper, see L.A. Birkenmajer 1900, pp. 350–388; Zathey 1972; Biskup 1973, p. 204, nr. 481; p. 209, nr. 493; p. 213, nr. 503; Wasiutyński 2003, p. 336.

[25] See Copernicus 1978. Regarding mathematical and methodological issues of *Commentariolu*s and *De revolutionibus* see fn. 154.

4.1. Works of Copernicus

- **C:** *Commentariolus* of Nicolaus Copernicus (1501–1514, probably ca. 1508–1512).
- **M:** *Meditata* of Nicolaus Copernicus (1517).
- **MCR:** *Monetae Cudendae Ratio* of Nicolaus Copernicus (1522, final edition 1528).
- **L:** *Letter against Werner* of Nicolaus Copernicus (1524).
- **R:** *De revolutionibus* of Nicolaus Copernicus (1543).

4.2. Works of other authors[26]

- **PR:** Peuerbach & Regiomontanus "*Epitoma in Almagestum Ptolemaei*" (1496).[27]
- **GV:** Georgio Valla "*De expetendis et fugiendis rebus*" (1501).[28]
- **AB:** Albertus de Brudzewo "*Commentariolum super Theoricas novas planetarum Georgia Purbachii*" (1482/1900).[29]
- **CC:** Celio Calcagnini "*Quomodo coelum stet, terra moveatur, vel de perenni motu terrae Commentatio*" (ca. 1525 printed posthumously in 1544).[30]
- **JG:** John of Głogów (Jan z Głogowa) "*Introductorium co[m]pendiosum in Tractatu[m] spere materialis*" (1513).[31]
- **MW:** *Abstemius* (Mikołaj Wodka of Kwidzyn) – some letters (1464, 1477, 1480, 1485, 1492).[32]
- **MB:** *Martini Biem de Olkusz* (Marcin Biem of Olkusz) "*Poloni nova calendarii Romani reformatio*" (1516/1918).[33]
- **A:** All above-mentioned seven texts taken together, non-Copernican corpus.

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[26] We will provide the reason for why these works were selected later on – see fn. 84.

[27] See Peuerbach 1496.

[28] See Valla 1501.

[29] See Albert of Brudzewo 1900.

[30] See Calcagnini 1544, pp. 388–395; Wołyński 1873, pp. 57–59; Hipler 1879, pp. 575–586; 1882, pp. 51–82; L.A. Birkenmajer 1900, pp. 480–491; Thorndike 1941, p. 409; Omodeo 2014, pp. 209–213.

[31] See John of Głogów 1513.

[32] See L.A. Birkenmajer 1926, and fn. 222, 224.

[33] See Biem 1918.

4.3. Miscellaneous technical terms

- **MFW:** Most Frequent Words.[34]
- **NLP:** Natural Language Processing (or Processor).[35]
- **POS:** Pairs Of Synonyms.[36]
- **CUB**: Chebyshev inequality Upper Bound.[37]

5. Yet another portrait 'Copernicus as a changing Latin writer'

The idea to compare Copernicus's texts with each other is also not new. However, the focus of the researchers so far has been on the semantic differences only and mostly between **C** and **R**. Obviously, the cosmology of these two works is not the same.[38] But the terms used are quite different too. A discussion of this matter can be found in many papers.[39] Different words are used for some important astronomical notions:[40]

Table 1.

	C	**R**
Sphere of the fixed stars	– *firmamentum*	– *stellarum fixarum sphaera* – *non errantium stellarum sphaera*[41]

[34] An important notion in stylometry representing the words most frequently occurring in a text. See Savoy 2020, pp. 93–94.

[35] The software providing tools for automatic text parsing and analysis. See Savoy 2020, p. 256.

[36] See section 8.4 below. In stylometry, the abbreviation POS (or PoS) is usually used to denote 'Parts of Speech'. Please note that we have adopted a different convention in this article.

[37] The so-called Chebyshev inequality provides an upper bound for the probability of a random variable to deviate from its expected value by some specified amount, provided the expected value and a variation exist. We recommend: Mitzenmacher, Upfal 2005, pp. 48–49 or Shoup 2009, pp. 241–244 as an easy introduction.

[38] See L.A. Birkenmajer 1900, pp. 71–80; A. Birkenmajer 1933; Swerdlow, Neugebauer 1984; Kokowski 1996; 2004; 2009a, entry "*Commentariolus*". See also fn. 154.

[39] E.g. in L.A. Birkenmajer 1900, pp. 81–82; Kopernikus, Kepler 1948 edited by F. Roßmann (reprinted in 1974).

[40] Perhaps, the most complete list of differences can be found in L.A. Birkenmajer 1900, p. 81.

[41] This alternative term for the "Sphere of the fixed stars" has been noticed by Edward Rosen (1939; 2nd ed. 1959; 3rd ed. 1971).

Planets	– *sydera* – *erratici*	– *errantes* – *errantia sidera*[42] – *errantes stellae* – *planetae* (not in I.1–10)
Earth's orbit	– *magnus orbis*	– *circulus terrae* – *orbis terrae* (not in I.1–10, but in V and VI, *orbis lunaris* in I.10) – *magnus orbis terrae* (not in I.1–10, but in V and VI)
Apsides	– *absides*	– *summa absis* / *apogaeum* – *infima absis* / *perigaeum*

Edward Rosen has also briefly touched on this subject[43]. According to him, Copernicus used "*firmamamentum*[44]" (*rather than "stellarum fixarum sphaera"* or *"non errantium stellarum sphaera"*) in **C** simply because "that paper, devoted almost entirely to planetary theory, seldom refers to the sphere of the fixed stars". Elsewhere in the same work, Edward Rosen mentioned the ambiguous use of *orbis* in **C**, which seems sometimes to refer to a two-dimensional *circulus*, sometimes to three-dimensional *sphaera* and in certain cases might even mean "planet". All these issues with somewhat shaky terminology were carefully explained away: "Although Copernicus wrenched astronomy loose from its geocentric past, his sentences abound in language that presupposes the Earth to be in the center of the universe. The revolution in ideas did not at once precipitate a complete transformation of the terminology". In other words, presumably, by the time of writing **R**, Copernicus drifted much further away from his geocentric terminological past. Characteristically, this whole discussion is in fact tangential to the main purpose of Edward Rosen's text, i.e. to clear Copernicus from the charge of thinking of **R** in terms of solid spheres.

Peculiarly, a "hypothesis" is absent in the text of **C**. This word deserves special treatment. To be more exact, it does appear in the

[42] Roßmann has '*errantes sidera*', but *sidera* is neutral, so '*errantia*' is correct.

[43] In the Introduction to *Three Copernican Treaties* – see Rosen 1939; 2nd ed. 1959; 3rd ed. 1971.

[44] Noteworthy is that this term preferred by Copernicus in his early work can also be found in the writings of his Polish professors – Albertus de Brudzewo and John of Głogów. See Maciąg-Fiedler 2016, pp. 118–119.

full title *"Nicolai Copernici de hypothesibus motuum coelestium a se constitutis commentariolus"* as it is known today.[45] According to Leszek Hajdukiewicz, with the exception of the words "*Nicolai Copernici*," the rest of the title could have been authentic.[46] In fact, the title is typical for the 16th–17th century – but as given by the third parties, such as publishers, not by the author himself.[47] Hence, we doubt the correctness of Leszek Hajdukiewicz's statement.

When Maximilian Curtze for the first time published the recently found **C**,[48] he considered "hypothesis" (in the sense of conjecture and a means of calculation) to be an intentional choice of word by Copernicus. Leopold Prowe[49] did not agree with him – Copernicus allegedly would not regard his idea as a mere hypothesis. Ludwik Antoni Birkenmajer had a similar view and instead of the title *Nicolai Copernici de hypothesibus motuum coelestium a se constitutis commentariolus* he only used *Zarys nowego mechanizmu świata* [*Outline of the new world mechanism*], briefly *Zarys / Commentariolus*[50]. But then Edward Rosen[51] added some fuel to the flame of controversy, pointing out to the historical semantics of the word "hypothesis," which used to be different in comparison with the contemporary usage of the word. This instrumentalist interpretation of "hypothesis" became common from the turn of the 19th century, but originated at least in the Middle Ages and was actually proclaimed by Andreas Osiander, the true author of the anonymous preface to the first edition of the **R**.

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[45] However, this title might have been devised by Tycho Brahe or Tadeáš Hajek. See Prowe 1883–1884, reprinted 1967, vol. I, part 2, p. 285 & fn.*; L.A. Birkenmajer 1900, p. 70, fn. 1, pp. 83–84, 634–635, and Appendix 1.2.

[46] See Hajdukiewicz 1960.

[47] See, for example, Kromer 1555 – '*Martini Cromeri Varmienis Episcopi Polonia siue De origine et rebvs gestis Polonorvm libri XXX. Oratio fvnebris Sigismvndi Primi regis, deqve situ, popvlis, moribvs, magistratibus et Republica regni Poloniae libri duo... (Basileae: Ex Officina Joannis Oporini)*'. And there are many similar titles, as can be easily seen in catalogues such as Koehlerówna, Dobrzyńska-Rybicka (oprac.) 1929.

[48] Curtze 1878, p. 5, footnote.

[49] Prowe, Nicolaus Coppernicus 1883–1884, reprinted 1967, vol. I, Part 2, p. 288, fn.*.

[50] L.A. Birkenmajer (1900, pp. 70, fn. 1, 83–84; 634–637; 1924, pp. 199–224; Kopernik 1920 (edited by L.A. Birkenmajer), pp. 19, 29, 40.

[51] Rosen 1937; Rosen 1939 (2nd ed. 1959; 3rd ed. 1971).

> For Copernicus a hypothesis is not only a means of calculation but also a statement of what is physically true. Thus, the real motion of the Earth is a hypothesis: *Id enim ex hypothesi motus terrae sequi videtur...* (Th I63.2); *... quae omnia huic quoque nostrae hypothesi mobilitatis terrae... plane sunt convenientia* (Th 345.20–21); *... per hanc hypothesim mobilitatis terrae...* (Th 357.I2); *... nostrae hypothesi mobilitatis terrenae ...* (Th 365.5–6)[52].
>
> [According to the ancients and Copernicus himself] fundamental propositions [of a theory] are termed *principium*, *assumptio*, and *hypothesis* without any distinction […] Before these principles, assumptions, or hypotheses can be accepted as true, they must meet two requirements. First, they must save the appearances (*apparentias salvare*): the results deduced from them must agree with the observed phenomena within satisfactory limits of error. Secondly, they must be consistent with certain preconceptions, called 'axioms of physics', such as that every celestial motion is circular, every celestial motion is uniform, and so forth. Disagreement with the observations is no more grave a defect than departure from the axiom of uniform motion: *apparentias salvare* and *aequalitatem tueri* are equally essential.[53]

We can agree with Rosen on this point.[54] Nevertheless, the record dated 1 May 1514 *Item sexternus Theorice asserentis Terram moveri, Solem vero quiescere* in the catalog of Maciej of Miechów's library[55] explicitly

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[52] Rosen 1937, p. 124, fn. 9.

[53] Rosen 1939 (2nd ed. 1959; 3rd ed. 1971), p. 29.

[54] The same position was propounded by Johannes Kepler in *Astronomia Nova* (1609) – see Kepler 1992, p. 28; L.A. Birkenmajer (1900, pp. 649–651). Such a stance in the philosophy of mathematical-physical sciences (or exact sciences), is called by M. Kokowski the "hypothetical scientific realism or moderate physico-mathematical realism". It has a long tradition stemming from Plato's *Timaeos* and Ptolemy's *Almagest* – cf. Kokowski 1996; 2004 (Platonism$_1$: Plato's mathematical abstractionism, Platonism$_2$: Plato's mathematico-physical hypotheticism); 2009a (entry "hipoteza"). Three other works are worth mentioning in this context: Zbigniew Jordan (1937, chap. IV "On the applicability of mathematics in natural sciences" (in Polish)); Jardine 1979; Musgrave 1991 ("critical realism").

[55] L.A. Birkenmajer 1924, pp. 200–202, 208; Hajdukiewicz 1960, p. 384.

mentions the moving Earth and the static Sun, so the common opinion of historians[56] is that it can only refer to the **C**. This description mentions no "hypothesis". Hence, using Kepler's expression here from *Astronomia Nova*, Curtze's hypothesis of "hypothesis" in the title of *Commentariolus* "go[es] up in smoke."[57]

Some other mismatches in terms between **C** and **R** can easily be found:

Table 2.

	C	**R**
Diameter	– *diametrum*	– *dimetiens* – *diametrum*
Predecessors in general	– *maiores nostri* – *physiologi* – *sapientes*	– *priores* – *antiqui* – *prisci philosophi* – *philosophi* – *prisci (alii … alii … multi vero priscorum)*
Ptolemaeus	– *Ptolemaeus*	– *C. Ptolemaeus Alexandrinus, Ptolemaeus Alexandrinus*
Al-Battani	– *Albategni Chaldaeus*	– *Machometes Aracensis / Albategnius Aracensis*

However, these kinds of findings have never allowed researchers to draw any substantial conclusions. As mentioned above, the differences were attributed to a presumably[58] long time spent between writing **C** and **R** and/or different topics/literary genres. Our idea was not only to compare the works but to do it on the level of the Latin language – tracing stylistic similarities and differences using both qualitative and quantitative approaches. We shall proceed to the former first.

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[56] E.g. L.A. Birkenmajer 1924, pp. 199–224; Rosen 1939, 3rd ed. 1971, pp. 6–7; Swerdlow 1973, p. 423; Kokowski 2006, p. 277.

[57] Kepler 1992, Part IV, chap. 55, p. 542.

[58] Some parts of *De Revolutionibus* might have been written within several years after *Commentariolus*. See L.A. Birkenmajer 1900, pp. 350–388.

6. Qualitative comparison

The results mentioned below can be seen as driven by the text semantics and in certain cases are based on sheer experience and/or intuition. It is normally recommended[59] to study stylistic and lexical characteristics separately. Therefore, our report below is grouped correspondingly and divided into sections discussing similarities and differences.

6.1. Stylistic similarities

1. All the texts are very concise:
   - **C** – the structure is indicated by means of headings. In addition, the author also uses signal words. There are enumerations that announce the number of arguments: *triplici motu … Uno, Alius Telluris motus est, Tertius est motus; quatuor motibus … alterum, demum; Primus enim, alter vero; primam, alia; duplici causa …* Also: *Hipparchus…, Albategni vero Chaldaeus… . Rursus autem Hispalensis…*
   - **M** begins with a definition. It has clearly structured argumentation through enumeration. There are announcements of the number of arguments, often with a numeral, then signal words. For example 19–29: *… tribus modis … vel propter … vel propter … vel, quod peius, propter … eciam propter … eciam ultro … . 35–37: duplici ratione … enim … Maximus vero error est … . 94–97: Primum est ut … deinceps …* (First ... then ...).
   - **L** – clearly structured argumentation using enumerations. Copernicus checks off Werner's errors one by one: *Primum igitur fefellit illum supputatio temporum … Alius error est … Nullo demum loco ineptior est quam …* (In the first place… Another error… Finally).
   - **R** – again clearly structured argumentation through enumerations. No numerals like in **M**, but rather: *plures, multiplici* (many, various) or no continuation signals at all. Examples from chapter I.4:
     – *Sunt autem plures penes orbium multitudinem motus. Apertissima omnium est cotidiana revolutio, quam… Deinde alias revolutiones…*

[59] Kestemont 2012.

  - *Sunt tamen in multiplici differentia: Primum, quod… Deinde, quod… Adde etiam quod…*
  - *Id enim evenire oporteret, vel propter … , vel propter…*
  - *sive quod… sive quod… sive etiam quod…*

2. Copernicus uses a depersonalized, and therefore objective and scientific language, the passive voice and gerundives of obligation are quite frequent.
   - **C** Introduction – *imaginarentur, demonstrationes omittendas arbitratus sum. De Venere: cernitur; aspiciuntur; nullum ... vestigium ... reperitur. De Mercurio: percipiatur.*
   - **M** 1–2: *qua … numerantur.* And 91–92: *Utinam reformentur hec.*
   - **L**: *animadvertendum puto … ; … deprehensum est a nobis … ; Illud quoque praetereundum non est; Quod etiam … erat observandum; Videndum igitur nobis nunc est; … quid … existimandum sit.*
   - **R** I. 1: *advertendum nobis est; conspiciantur.* I. 2: *a navigantibus deprehenditur, cernitur, spectatur.* I. 4: *putatur*, *intelligitur*, *deprehenduntur*, *intelliguntur.* I. 5: *percipitur, aspicitur, reproducitur.*
3. Passionate judgment, as certain sentences show a strong opinion, for example:
   - **C***: Consequens est ut, procul dubio, necesse est, sane.* Conditionals, and logical reasoning the reader has to go along with if he accepts the condition in the if clause: *Si quis autem diligentius perscrutetur … haud facile dubitabit.*
   - **M** 91–92*: Utinam reformentur hec, dum tempus est, ante ruinam maiorem …*
   - **L***:* Invitation to participate in the discussion with conditional clauses: *Si quis dubitet … meminisse debet… ; si … numeret, non inveniet… , sed… ; Quod si coniungas… , deficiet…* Rhetorical question: *quid aliud restat, quam…* Use *certe, nempe, videlicet, consequens est, igitur, ergo*, and very strong adversative conjunctions like *e contrario vero, cum tamen in nulla parte*. Use of sarcasm, the "compliment" is meant to be taken as the opposite, he brings down Werner by showing he made a mistake: *Sed hic tantus mathematicus existent non advertit ...* (but being a great astronomer, he is not aware…).
   - **R***:* frequent use of rhetorical questions. *Quid (enim) aliud est quam… ? (I.3, I.8), Sed cur non illud… ? (I.8) Quid ergo aliud volunt significare, quam… ; In medio vero omnium residet Sol. Quis enim*

in hoc pulcherrimo templo lampadem hanc in alio vel meliori loco poneret, quam unde totum simul possit illuminare? (I.10). Certainty is conveyed by means of: *nempe, nimirum, certe, quippe, sane, videlicet, scilicet*.

6.2. Stylistic differences

1. Ablative absolute constructions occur more frequently in C and they are quite long.
   - Examples from **C** Introduction: *omnibus in se ipsis aequaliter motis; firmamento immobili permanente ac ultimo caelo; His igitur sic praemissis*.
   - Examples from **C** paragraph *De Venere: motu terrae superante … superato … orbe Telluris contento … continente; incidente Terra; decrescente hac inflexione; libramento continuato et … declinante ac … elongante*.
   - In **M** and **L**, Copernicus uses ablative absolute constructions only once or twice. **M**: *Manente autem adhuc antiqua partim moneta…* **L***: vix evadente Ptolemaeo* ('while Ptolemy barely escaped') *en dissipato ipso iam fundamento* ('But now that the underpinning itself has been destroyed').
2. Also in **R** there are few of them and they are short. In the letter of dedication: *favente Deo*. I.10: *Hinc sumpta occasione…*
3. **C** makes use of predicative present participles more often. Examples from the Introduction: *Calippus et Eudoxus … deducere laborantes non potuerunt et … reddere rationem; Solem … existentem; Summus (orbis) est … omnia continens et locans*. Examples from paragraph *De Venere: Orbis … facit … eoque motu … restituit … constituens; … epicyclus … habens … reservavit*.
4. The emphasizing or explanatory conjunction *quidem* is frequently used in **C**. It is mostly used for emphasis, sometimes in an elucidation of what precedes. It hardly occurs in the other works of Copernicus.
5. It is also striking that the summarizing or concluding conjunction *ergo* does not occur in **C** (while it is often used in **R**/**M**). *Igitur* is preferred**,** occasionally *ideoque*, *itaque*.
6. **C** prefers *ut / sicut dictum est* over *ut diximus*. In **L** there is no preference (*ut dixi* and *ut dictum est* both occur), in **R** Copernicus only uses *ut diximus / dicebamus*, there is no *sicut* at all.

7. The first-person plural. Copernicus normally uses the first-person plural only in certain situations. First, when he speaks on general observations everybody can make. Second, when indicating what he is going to discuss next or what has been discussed elsewhere, for example: *Post haec memorabimus* (I shall now recall to mind) or: *ut diximus* (as I mentioned). In **C** the first-person plural is used in other contexts as well:
   - *ne quis temere mobilitatem Telluris asseverasse … nos arbitretur, …* (lest anybody suppose that … I have asserted the Earth's motion gratuitously). This is not a general observation, nor an announcement of what is to be discussed or what has been discussed. Compare it with the following sentence from the letter of dedication of **R** where both contents (the expected rejection of his theory) and syntax (accusative-with-infinitive construction) match: *ut … statim me explodendum … clamitent.*
   - *hanc speculationem nostram*. Compare this with the letter of dedication of **R**, in which Copernicus prefers *meus* above *noster* when speaking of his own work: *hisce meis libris, meos commentarios, meam operam, meas lucubrationes, meum hoc institutum*, and finally, used only once: *nostri labores.*
   - *cum etiam propter apparentiam versemus eandem* – since I undermine the Earth's immobility as likewise due to an appearance / since I explain the appearances also. Used not in the general sense "we, as human beings" or "we, as astronomers," on the contrary, he responds negatively to the general opinion here.[60]
8. Humanistic vs. scholastic. A first intuitive impression of **C** shows that it is quite different from the other texts. In general, Copernicus's Latin style is, perhaps not Ciceronian, but quite clear, smooth and even elegant – it is, in short, humanistic, Renaissance Latin.[61] That does not seem the case for **C**. It feels inscrutable and difficult to follow, sometimes even simply bad (perhaps, scholastic, medieval) Latin.[62] In **C** there are no proverbs or sayings, no

[60] However, if the correct reading is not "*versemus*", but "*versemur*", then you could translate this first-person plural as "we, as human beings here on Earth."

[61] *Cf.* discussion in section 2 of the present paper.

[62] *NB:* The Latin of *Commentariolus* has never been analyzed separately before – see section 2 above.

self-invented metaphors, no Grecisms.[63] The introduction is quite short, and it does not stress the points present elsewhere, such as the author's humility or the usefulness of science. Furthermore, it is not clearly demarcated with signal words, as in **L** (*Primum igitur*) and the letter of dedication in **R** (*nunc ad institutum transeo; Principio* ...). The list of postulates in **C** is unique: Copernicus's style has been often characterized as concise[64] but one of the conclusions of the present research is that he normally writes clearly structured prose and would indicate enumerations by means of continuation signals rather than by lists.

6.3. Conclusion of qualitative comparison and its limitations

The stylistic differences found so far by the qualitative comparison cannot be so easily discounted. It is no wonder then that the Dutch neo-Latin expert Prof. Dr. Jan Bloemendal from the Huygens Institute for the History of the Netherlands, Royal Netherlands Academy of Arts and Sciences, invited to express his opinion, stated categorically:

> it is not probable that *Commentariolus* on the one side and *De Revolutionibus* on the other side belong to the same author.

It appears as if instead of an intended elucidation of some details on Copernicus, we unexpectedly got stuck in yet another controversy about him. Based on the qualitative linguistic analysis of **C** and **R**, we might be inclined to believe that there was a forgotten outstanding mathematician–astronomer–physicist in the Kraków milieu, whose work was later continued by Copernicus.[65] Let us check how the working pseudo-Copernicus thesis squares with the other historical facts known to us. Fortunately, there exists an easy and perfectly secure way to confirm Copernicus's authorship of **C**. It is based upon 16 pages[66] inserted by Copernicus into the book which used to belong to him, currently

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[63] A possible exception is:"*Video equidem in vilioribus rebus, quod virgula ferrea magnete attrita in vnum semper mundi situm nitatur*," which perhaps can be counted as a comparison. *NB*: The lack of Grecisms has been noticed by L.A. Birkenmajer (1900, pp. 81–82).

[64] See section 2 above and Kowalski 1924.

[65] Such a thesis would be analogous to the thesis of Pierre Duhem (1909/1910) that Nicole Oresme was a forerunner of Copernicus – see Kokowski 2009a, pp. 326–328.

[66] So-called *Raptularzyk upsalski* (in Polish) or *Uppsala Notes* (in English).

located in the Swedish Uppsala library.[67] This small and humble notepad attracted the attention of quite a number of prominent researchers. It was originally found by Leopold Prowe[68], then mentioned by Franz Hipler[69], described by Maximilian Curtze[70] and thoroughly analyzed by Ludwik Antoni Birkenmajer[71]. During the celebration of Copernicus 500-year anniversary, Noel Swerdlow[72] focused the attention of Western historians of science on a certain page from it, which he named the "U-document"[73]. The point is that the **U** in a recognizably Copernicus's handwriting contains some numeric parameters used in **C**. The direction **U** → **C** rather than vice versa can be deduced from the rounding of the values (radii of Mercury's epicycles). "Further, the numbers in the lower part of U are derived from the numbers in the upper part. U therefore came prior to the *Commentariolus*" – Swerdlow rightly concluded, following actually the idea of L.A. Birkenmajer stated back in 1900.[74]

Hence, we have perhaps reached the end of the announced controversy but are still not at the end of our quest. Could it be that some human mistakes are responsible for the strange outcome of the qualitative comparison? Let us supplement it with a machine-based quantitative research. This has traditionally been the domain of so-called stylometry. Therefore, a quick introduction to this scientific discipline is in order.

7. Stylo(-chrono-)metry

The idea that the style of a text reflects its author in a similar fashion as the appearance, fingerprints or signature does seem quite plausible. Accordingly, the first attempts to decipher this information can be dated to at least 15th century. Lorenzo Valla in his famous discovery

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[67] *Copernicana 4*. The Copernicus book collection kept in the Uppsala Library is a spoil of war from the time of the Swedish invasion of Warmia in 1626 – see: L.A. Birkenmajer, Collijn 1909; Barwiński, L.A. Birkenmajer, Łoś 1914; Czartoryski 1978; Grabowska 2010.

[68] Prowe 1858, p. 11.

[69] Hipler 1872, p. 60, fn. 51.

[70] Curtze 1878, pp. 27–57.

[71] L.A. Birkenmajer 1900, chap. III (*Commentariolus*) and VII (*Raptularzyk upsalski*).

[72] Swerdlow 1973. The document is also translated into English and has been commented on by Edward Rosen in Copernicus 1985.

[73] This was also discussed in L.A. Birkenmajer 1900, pp. 202–207.

[74] *Ibid.* pp. 80–81, 160–161, 164, 196–197.

of the forgery of "Donation of Constantine", followed something akin to the qualitative methodology that we used above. It was his contemporary Leon Batista Alberti (1404–1472), who suggested performing a quantitative measurement,[75] i.e. stylometry *sensu stricto*. The term "stylometry" itself was coined by a prominent Polish philosopher, Wincenty Lutosławski.[76] This young science acquired a somewhat dubious reputation later on when it was applied to such problems as attribution of Biblical writings[77] or Shakespeare plays. However, recent advances of the computer technology and the further development of concise mathematical models slowly changed the situation for the better.[78] It is no longer a domain of pure speculation – some recent experimental research in the field of social psychology does seem to confirm this statement.[79] The stylometry nowadays is deservedly a fully-fledged member of "Digital humanities". Obviously, its conclusions are valid only if the following postulates, which are called elsewhere axioms, were true:

- P1: There is no one common writing style but rather a great variety of them.
- P2: Some style markers are of such nature that they cannot be manipulated consciously and barely depend on the genre or topic, so they reveal the author personality.
- P3: These style markers remain quite stable during the whole mature life of each person.
- P4: By discovering and comparing these markers it is possible to determine with a high probability which writings belong to the same and which to different authors.

  This premise is clearly intended for the authorship attribution and verification, which is hardly relevant for us. However, stylometry is currently also actively used for other purposes, namely for profiling authors[80] and so-called stylochronometry[81]:

[75] Savoy 2020, p. 32, we would also like to recommend this book as a great introduction for beginners in stylometry.

[76] See Lutosławski 1897; 1898; Pawłowski, Pacewicz 2004; *Mróz* 2018.

[77] E.g, to the authorship of the Pauline epistles.

[78] A good overview of the remaining caveats can be found in Rudman 1998.

[79] Kacewicz et al. 2014.

[80] I.e. deriving some author characteristics, such as age, gender, social strata, psychological state etc. See Pennebaker 2011.

[81] I.e. dating of the texts based on the style markers. This scientific pursuit also has a long history, being applied by Wincenty Lutosławski in 1897; 1898 to determine the

- P5: Some style markers reveal the current psychological state of the author at the moment of writing and/or the relationship to the intended audience.
- P6: Some style markers change in a predictable fashion over time. Thus, they can be used to determine with a high probability the dating of texts or at least the sequence in which they have been written.

These premises look, *prima facie*, if not doubtless then at least plausible. However, P3, P5 and P6 are clearly in a state of mutual logical conflict. It is resolved in a straightforward fashion – the style markers meant in all these propositions are simply different. This consideration brings us to the first issue – how to pick out and calculate these elusive text features. There are in fact much too many techniques and algorithms available on the scientific shelf.[82] The difficulty of our task is exacerbated by the following issues:

- Lack of data. There are 3 items that are required for the success of a stylometric investigation: data, more data and even more data. With the available Copernicus texts, we clearly do not have them.[83] As the proposed solution we can add some counterexamples, *viz.* the books which were written not by Copernicus himself but by his contemporaries, preferably in a similar genre and topic, ideally those he was familiar with. We selected the authors and works, already mentioned in section 4.2.[84];

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chronological sequence of Plato dialogues. For the modern applications see Stamou 2008; Klaussner, Vogel 2015.

[82] See Holmes 1994; 1998; Savoy 2020.

[83] **R** is the only work of substantial size, the first book being around 12400 words, the rest of the treatise is a dry scientific text which lacks the required style markers. **C** is around 3350 words only, **L** – 2250, **M** – 1150.

[84] We selected these works based on the achievements of previous Copernican researchers. We know from the dedication letter of Wojciech of Bukowo of 27 September 1542 to Samuel Maciejowski, bishop of Plock (attached in his astrological forecast published in Kraków in 1542), and reprinted by Jan Brożek in 1618 in his work (without the appropriate title) that Copernicus studied at the University of Kraków and grew up to be his greatest fame – cf. Franke 1884, p. 55, so Copernicus could read the works or was familiar with the theories of scholars from this university. We also know from Franciszek Karliński (1873, pp. 8–13) and Ludwik Antoni Birkenmajer (1924, pp. 54–141) of a list of professors at the University of Kraków, including those who gave lectures during Copernicus's stay at this university. Ludwik Antoni Birkenmajer (1926) conjectured that Copernicus received his early education in Włocławek under

PR: Peuerbach & Regiomontanus "*Epitoma in Almagestum Ptolemaei*"[85] as one of the most important sources of **C**[86]**.**
GV: Georgio Valla "*De expetendis et fugiendis rebus*"[87] as another recognized source of **C**.[88]
AB: Albertus de Brudzewo "*Commentariolum super Theoricas novas planetarum Georgia Purbachii*"[89] as a probable big influence on Copernicus during his years at Kraków university.[90]
CC: Celio Calcagnini "*Opera aliquot*"[91] as a text by an early proponent of the moving Earth.[92]
JG: John of Głogów (Jan z Głogowa) "*Introductorium co[m]pendiosum in Tractatu[m] spere materialis*"[93] as a text by another author being a likely big influence on Copernicus during his university years in Kraków.[94]
MW: *Abstemius* (Mikołaj Wodka of Kwidzyn) – some letters of a possible pre-university teacher of Copernicus.[95]
MB: *Martini Biem de Olkusz* (Marcin Biem of Olkusz) "*Poloni nova calendarii Romani reformatio*"[96] as a text by the astronomer and friend of Copernicus.

- Poverty of rich language. Unfortunately, there is no adequate **NLP**[97] for Latin available.[98] It remains a rich and powerful but

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Abstemius (Mikołaj Wodka of Kwidzyn), so Copernicus's language use in some respects might be similar to Abstemius's. Additionally, from the comparative analyses carried out by Ludwik Antoni Birkenmajer it follows that Copernicus must have studied the works of Puerbach and Regiomontanus, Georgio Valla, Wojciech of Brudzewo, John of Głogów etc. – see the relevant bibliographic references below.

[85] Peuerbach 1496.
[86] L.A. Birkenmajer 1900, pp. 3–25.
[87] Valla 1501.
[88] L.A. Birkenmajer 1924, pp. 152–168.
[89] Brudzewo 1900. Edited by L.A. Birkenmajer.
[90] L.A. Birkenmajer 1924, pp. 83–103.
[91] See fn. 30.
[92] L.A. Birkenmajer 1924, pp. 169–192.
[93] John of Głogów 1513.
[94] L.A. Birkenmajer 1924, pp. 103–134.
[95] L.A. Birkenmajer 1926, pp. 125–138, and below fn. 222, 224.
[96] Biem 1918. Edited by L.A. Birkenmajer.
[97] Natural Language Processor. See *Sigla* (section 4).
[98] Some positive advances in this direction such as Passarotti et al. 2017 and Bolt et al. 2019 can clearly not be used as ready solutions yet.

at the same time highly inflected and difficult language. Consequently, many style markers[99] are simply impossible to calculate. What remains are so-called function words,[100] and among them conjunctions since they are (unlike pronouns) not inflected and easy to count.

- Too rich diversity. The texts that we selected belong to more or less different genres and/or periods in the life of Copernicus. It remains a Holy Grail of stylometry to find such style markers that would be invariant of particular genre or topic. In general, we do not wish to pursue such an ambitious goal[101] in this paper but conjunctions are actually such high-frequency function words that cannot be avoided easily, and they are not bound to a particular genre or subject. They truly represent subconscious style elements, which are not supposed to change easily.
- Lack of software. The available stylometric software for text analysis has been developed for the modern languages and most of the time for a different purpose, namely the verification of authorship. Our task was much simpler since we only focused on the differences between **C** and Copernicus's other writings. This is why we decided not to use it[102] and instead develop our own simple word counting and database processing software.[103] The analysis and visualization of the obtained results (average value, standard deviation, charts etc.) was then performed with Wolfram Mathematica[104]. Due to the abundance of statistical results, we have decided to focus on the most important findings.

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[99] There are literally thousands of them: Rudman 1998; Savoy 2020. We avoided a computation-intensive calculation of word combinations since recent research (see Eder 2011) has found no essential benefits of using the word-pairs (-triples etc.) before the single words for the Latin language.

[100] I.e. words which bear no specific content.

[101] Perhaps the premise P2 is too strong in its genre-independency claim.

[102] With the only notable exception of LIWC program, see section 9 below.

[103] We used programming language C for the word counting first. Later on, we developed a VBA application in Microsoft® Access to facilitate the data analysis. The source texts are available upon request.

[104] See https://www.wolfram.com/mathematica.

8. Quantitative comparison

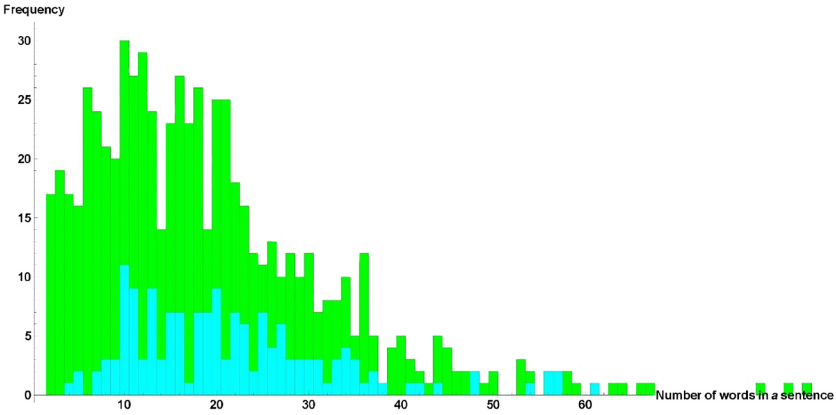
Let us start looking for Copernicus's style markers. This analysis is divided into three parts.

8.1. First steps

Certain procedures can be found in virtually every stylometric investigation.

- Preprocessing. The texts we assembled together differ in punctuation or spelling conventions, have editorial notices, non-Latin words or quotes inside. These simple issues are more than enough to hamper the most advanced software. So, it is essential to preprocess the data to get rid of them. E.g., here are some of the word replacements which we have made: *uel* → *vel, vt* → *ut, uero* → *vero, eciam* → *etiam, vbi* → *ubi, vnius* → *unius* and so on.
- Lengths of sentences.[105] Historically, this was one of the oldest proposed style markers.[106]

In the histogram below **R** and **C** are compared:



R: average 18.15, standard deviation 13.15. **C**: average 21.89, standard deviation 11.47

Chart 1.

[105] We used ".", "?", "!" (ASCII codes 046 063 033) as sentence delimiters. Some texts had non-standard sentence delimiters, which were replaced during the preprocessing stage.

[106] This style marker is gradually losing its rating for the simple reason that it can be consciously manipulated. See (Holmes, Authorship Attribution 1994).

The shapes of the histograms of Chart 1 are quite similar – long and short sentences alternate. In general, the differences in the average sentence length of all texts (including the whole non-Copernicus corpus **A**) are not statistically significant (for p-value < 0.05), which can be clearly seen on the Chart 2 depicting the mean values (they are represented as the colored bars) and the standard deviation (represented as the black vertical lines) for each text.

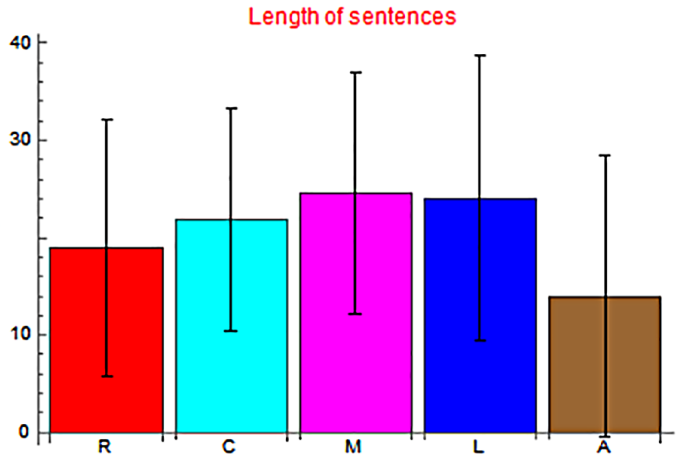


Chart 2.

- Zipf's law.[107] This statistical law, in plain words, claims that there should be many different words[108] with low frequency and vice versa. Mathematically, it comes down to an inverse relation between the so-called rank and frequency, which on a log-log plot is roughly represented as a descending line. All our texts follow this prescription[109]:

There are some statistical ways to fine-tune the word frequency distribution.[110] However, it would not deliver us more than a few style

[107] It is actually hardly a law but rather a curious empirical regularity. See Powers 1998.

[108] We used "A-Z", "a-z", "-", "0-9" (ASCII codes 065-090, 097-122, 045, 048-057) as legitimate inside the words, all the other characters were considered the delimiters.

[109] Only the declination angle is relevant. The larger texts occupy a naturally higher ground on the chart.

[110] Baayen 2001.

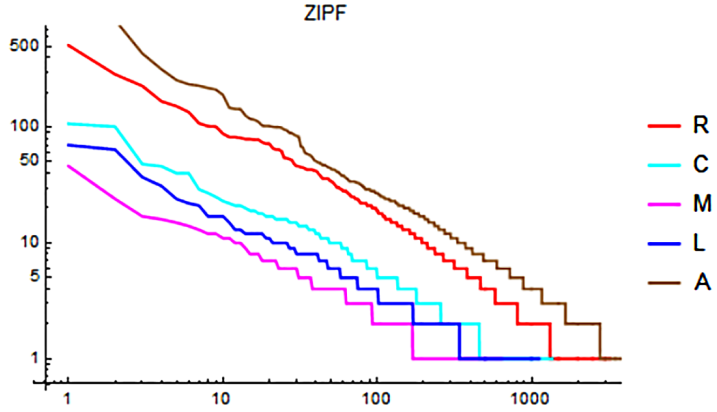


Chart 3.

markers of doubtful relevancy. So, we decided to proceed with our original plan and focus on the investigation of the function words.

8.2. Most Frequent Words

From the discussion of Zipf's law it should be clear that the absolute majority of the words in our texts occur just a few times. This is confirmed by the information in the table below:

Table 3.

Text	Words frequency	Percentage of the whole text
R	only once[111]	15.4%
R	<= 10 times	47.4%
C	only once	27.2%
C	<= 10 times	68.4%
M[112]	only once	40.0%
L[112]	only once	34.6%
A	only once	22.9%
A	<= 10 times	53.9%

[111] In stylometry these are also called *hapax legomena*.

[112] **M** and **L** are such small texts that most of the words occur less than 10 times.

Accordingly, to find the relevant style markers it would suffice to analyze as many **MFW**s as it takes to cover a big enough share of the remaining text. With 25 and 50 **MFW**s of each of the text joined together the following coverage is obtained:

Table 4.

MFWs	**R**	**C**	**L**	**M**	**A**
25	26.1%	22.3%	21.5%	23.3%	23.8%
50	30.6%	27.1%	27.4%	27.7%	27.3%

From Table 4 we have concluded that the twofold increase in the quantity of **MFW**s doubles the amount of work to be done but provides only a moderate increase in coverage. Besides, with 27–30% (see data in Table 3) we miss only a small fraction of the **MFW**s. So, the consequent analysis is based upon the choice of 50 **MFW**s. The following words have been selected (see data in Table 5).[113]

Notice*:* We have excluded the so-called content words (contrary to the function words they bear some content specific for the topic) manually by marking them with a prefix "*". From a total of 130 words this leaves 67. Some of these are inflected forms of the same words (e.g. *ea/eius/eorum/id, erit/esse/est/sunt* etc.). We did not use the Latin **NLP** but could have grouped them manually. However, since separating them from each other would provide more potential style markers which were so scarce and so important for us, we preferred not to do that. Besides, recent research has shown that "lemmatization, being a labour-intensive task, does not increase the attributive efficiency."[114] Finally, some of these **MFW**s could have been homonyms, i.e. have a different meaning with the same spelling. Such in-depth semantical analysis could arguably only provide minor perturbations in the calculation and therefore was also left beyond the scope of our investigation.

Now we are ready to compare the frequencies of each of them between **A** and Copernicus writings. To select only statistically significant differences, we calculated the average and standard deviation for them

[113] There are totally 130 of them since the intersection of **MFW** sets for our 4 texts is not empty.

[114] See Eder 2015.

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Table 5.

ab	*annorum	circa	erit	iam	*maioris	Non	qua	se	*stellarum
*ABC[115]	*annos	*contingit	esse	id	*marca	*novi	quae	secundum	sub
ac	ante	cum	est	igitur	*marce	*octavae	quam	sed	sunt
ad	*argenti	*datur	et	illi	*marcis	*orbe	que	semper	tamen
*aegritudo	*argentum	de	etiam	in	*moneta	*orbis	qui	si	*telluris
*aequales	atque	*dies	ex	ipsam	*monetam	*pecunia	quibus	sic	*terra
*aestimationem	aut	ea	fuerit	ita	*monete	Per	quidem	*sidus	*terrae
*anguli	autem	eius	fuisse	*latera	*motu	*pondere	quo	sit	tunc
*angulum	*BC	enim	*gradus	*latus	*motum	*primo	quod	sive	ubi
*angulus	*BD	eorum	haec	*libra	*motus	Pro	quoniam	*solidi	unius
*anni	*centro	*epicycli	hic	*libram	*mundi	propter	quoque	*solidis	ut
*annis	*centrum	ergo	his	*luna	nisi	*Ptolemaeum	*revolutiones	*solidorum	vel
*anno	*Christi	eris	hoc	*magni	nobis	*Ptolemaeus	*scoti	*sphaerae	vero

[115] ABC, BC, BD are ubiquitous in the geometrical part of **R**.

in the non-Copernicus corpus **A**. To do that **A** was segmented into chunks of 200[116] words, the **MFW**s were summed inside each segment to accumulate what is supposed to be the random sequence of counts. This produced the following data:

Table 6.

MFW	**A** average	**A** st. dev.	Book	Book average	Z-score[117]
tunc	0.058	0.265	**C**	0.938	3.321
unius	0.051	0.252	**L**	0.818	3.044
sub	0.146	0.394	**R**	1.323	2.987
unius	0.051	0.252	**C**	0.688	2.528
illi	0.073	0.312	**M**	0.800	2.330
quoniam	0.094	0.293	**R**	0.683	2.010
pro	0.175	0.568	**M**	1.167	1.746
sub	0.146	0.394	**M**	0.833	1.744
sive	0.044	0.318	**R**	0.571	1.657
ipsam	0.109	0.356	**M**	0.667	1.567
iam	0.234	0.518	**M**	1.000	1.479
etiam	0.594	0.816	**M**	1.800	1.478
qua	0.197	0.435	**M**	0.833	1.462
quidem	0.413	0.826	**C**	1.588	1.423
fuisse	0.124	0.391	**L**	0.667	1.389
haec	0.197	0.526	**C**	0.882	1.302
tunc	0.058	0.265	**M**	0.400	1.291
propter	0.219	0.615	**M**	1.000	1.270

[116] This looks like an *ad hoc* number but it is not. Just like with the MFWs we also tried different segmentations but got very similar results.

[117] We consciously did not use a weaker T-score to avoid the overoptimistic results. For a quick introduction into the world of statistics we recommend Foster, Diamond, Jefferies 2015.

his	0.146	0.375	**C**	0.588	1.179
ante	0.168	0.479	**L**	0.727	1.167
eorum	0.196	0.538	**M**	0.800	1.123
hic	0.210	0.546	**C**	0.813	1.104
qua	0.197	0.434	**L**	0.667	1.083
enim	0.725	0.877	**M**	1.667	1.074
quoque	0.246	0.480	**R**	0.762	1.075
circa	0.239	0.679	**C**	0.941	1.034
in	6.058	3.866	**M**	2.167	-1.006

8.3. Style markers

It is somewhere inside the above-mentioned function words[118] that Copernicus's "ruling planets" (style markers) are hidden. However, our present aim at this point is to compare **C** with the rest of Copernicus's writings. So, we repeat the same procedure for **C** only, taking now **R** as an anchor.[119] Here is the outcome:

Table 7.

MFW	**R** Average	**R** St. Dev.	Book	Book average	Z-score
quidem	0.129	0.338	**C**	1.588	4.317
tunc	0.065	0.248	**C**	0.938	3.520
hic	0.080	0.275	**C**	0.813	2.665
autem	0.726	0.853	**C**	2.059	1.563
unius	0.145	0.399	**C**	0.688	1.361
haec	0.258	0.510	**C**	0.882	1.224

[118] Perhaps, a logical conjunction of some of them.

[119] I.e. it is now for **R** that we calculated the average and the standard deviation as the basis for the subsequent comparison.

The results are quite noteworthy. For 3 **MFW**s[120] the corresponding p-value[121] is (much) smaller than the usual significance level 0.05[122], which means that statistically it is hardly possible that it can be due to a chance. Let us visualize our findings (including the averages of **M** and **L**) in charts:

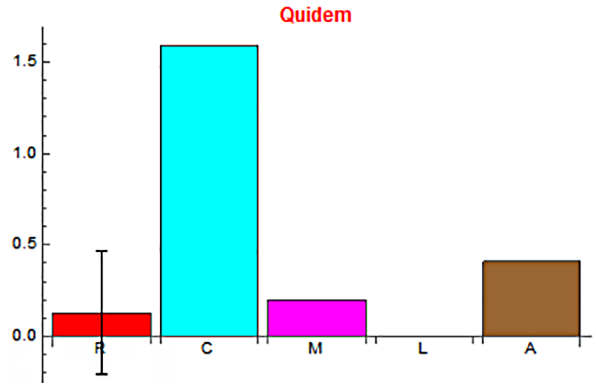

Chart 4.

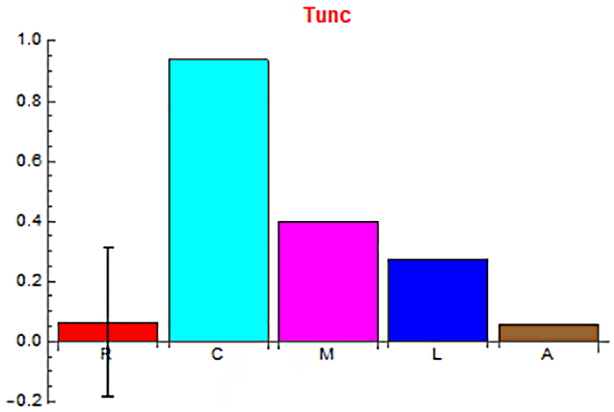

Chart 5.

[120] From them only *quidem* was found by the qualitative assessment.

[121] We assumed a normal distribution – here and throughout the paper. Since this commonly made assumption is quite weak, the results obtained under it look less rather than more spectacular. Note that the distribution of words is a more complicated issue – cf. e.g. Parker-Rhodes, Joyce 1956; 1957; Good 1957; Baayen, R. Harald 2001.

[122] Two-tailed hypothesis, |Z-score| is (much) greater than 2.

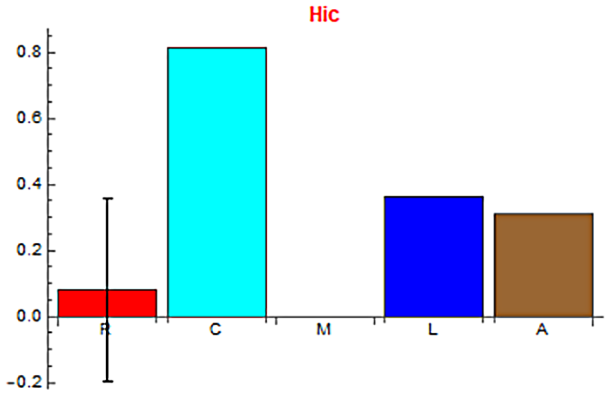

Chart 6.

There is more evidence confirming these results, which will be discussed in the following section.

8.4. Synonymetry

It can be observed that the standard deviation calculated by using segmentation of the texts is nearly always greater than the average. This is due to the fact that a lot of data chunks for our **MFW**s get zero counts. Accordingly, under the assumption of normal distribution the bell shape looks "squashed" – it is wide and low. In other words, its information content is nearly negligible.[123] It could be that the underlying distribution assumption is too weak, causing the requirements for statistical significance to be too strong. This might make us miss some important style markers.

Luckily, there is a way to overcome this problem. Once again, Latin is a rich language with a high level of synonymy – many words, including some very primitive conjunctions, express similar, perhaps, even identical semantics. It seems then quite natural to assume that whenever an author wishes to express a certain semantics, the subconscious choice between a fixed number of alternative synonyms that is made, and the preference to use one linguistic construction rather than the other, does reflect the personal writing style. Unsurprisingly,

[123] Since the data can be anywhere within the standard deviation from the average with a reasonable probability.

the simple idea to measure this preference was followed by the very first stylometric researchers.[124] Some recent stylometric research also focuses on the counting of synonyms.[125]

In the mathematical model, which can be called "synonymetry", we represent the choice of synonyms as a random variable that takes discrete values – say, 0 and 1.[126] Let us call the respective probabilities p_0 and p_1 ($p_0 + p_1 = 1$). The process then can be seen as an unfair[127] coin toss every time the choice is made. In other words, under the assumption that the preference of one of the synonyms before the other is a genuine style marker, the underlying binomial distribution seems to be a justified hypothesis. The average probability of the choices made can be calculated for the whole corpus of writings and the upper bounds for deviations from these mean values can then be found by Chebyshev inequality[128] or even Chernoff bound[129]. The advantage of this approach is that the text size (to be more exact, the number of the occurrences) is explicitly taken into account while the spread of the words over the text is abstracted away.

For our quick investigation we selected only those Pairs Of Synonyms (**POS**) which met the following requirements:

- To ensure the high quantity of occurrences the words had to be taken from the previously found **MFW**s.

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[124] It was mentioned by Wincenty Lutosławski 1897; 1898;

[125] Love 2002, pp. 105–106, or Juola 2017. A slightly different approach can be found in Koppel, Akiva, Dagan 2006. It is also based on counting synonyms but introduces 'stability' as a style marker, which is supposed to measure the author propensity to use different synonyms for given semantics.

[126] Of course, there can be more than 2 synonyms to choose from. However, for simplicity's sake we can always focus on a fixed pair of them since their relative rate of occurrence under our assumption should remain constant. Alternatively, we can also divide the synonyms into two non-empty sets to be compared with each other.

[127] In general, p_0 and p_1 are not equal to 0.50 and *ex hypothesi* depend on the writing style.

[128] The so-called Chebyshev inequality provides an upper bound for the probability of a random variable to deviate from its expected value by some specified amount. We recommend Mitzenmacher, Upfal 2005, pp. 48–49, or Shoup 2009, pp. 241–244, as an easy introduction.

[129] Perhaps, we are not justified to use a much stronger Chernoff bound because it requires the mutual independence of the choices. Besides, our texts are much too short to get an appreciable difference with the Chebyshev inequality anyway.

- To serve as genuine style markers the chosen by us **POS** had to show stable **CUB**[130] over the whole text of R.
  With these restrictions we have managed to find two high-quality **POS**. On the chart below the remarkable stability of the **CUB**[131] can be seen:

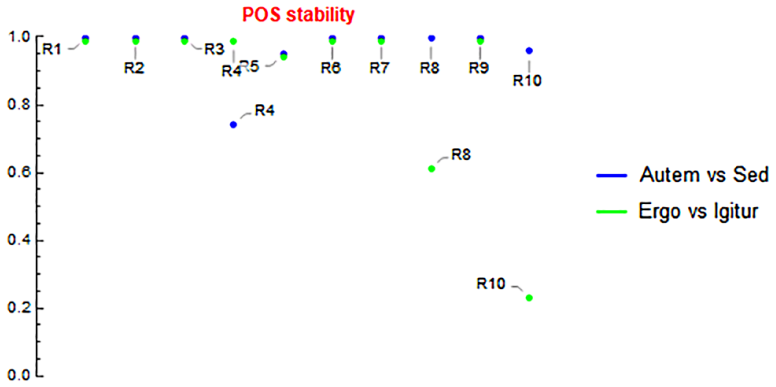

Chart 7.

Below are the synonymetric results for these two style markers:

- *Sed vs Autem*[132]:

Table 8.

Book	n (total occurrences)	n_0(*Sed* count)	n_1(*Autem* count)	p_0(*Sed*)	p_1(*Autem*)	**CUB**[133]
R	89	44	45	0.495	0.505	–[134]
C	61	21	40	0.349	0.651	≤ **0.19410**
M	14	4	10	0.313	0.687	≤ 0.53900
L	20	12	8	0.591	0.409	≤1[135]

[130] **CUB –** Chebyshev inequality Upper Bound.

[131] R1 – R10 on the chart represent 10 segments of **R**.

[132] *Sed* is normally translated as 'But' but *Autem* as 'However'. However, semantically they both represent a negation of the aforementioned and the corresponding meaning can be represented by either of them. Obviously, a much deeper insight into the text semantics (using the Latin **NLP)** would be very welcome for future research.

[133] It is calculated as **CUB** = min ($p_0p_1/n\varepsilon^2$, 1). Here ε is the p_0 (**Book**) – p_0 (**R**).

[134] **R** has been taken as the comparison basis; this is why no value is applicable here.

[135] In this case **CUB** = min (1.34484, 1) = 1.

NB: For **C** the Chebyshev inequality provides a generous upper bound on the probability to get 40 **or more** "*autem*"-s from 61 occurrences of the pair "*sed-autem*".

- *Ergo* vs *Igitur* is even more striking:

Table 9.

Book	n (total occurrences)	n_0(*Ergo* count)	n_1(*Igitur* count)	p_0(*Ergo*)	p_1(*Igitur*)	**CUB**
R	118	54	64	0.458	0.542	–
C	19	0	19	0.048[136]	0.952	≤ **0.07746**
M	8	6	2	0.700	0.300	≤ 0.53136
L	7	4	3	0.556	0.444	≤ 1[137]

NB: The upper bound for probability of all these deviations occurring simultaneously is: 0.194* 0.077 ≈ 0.015. So, these are hardly coincidences but *bona fide* personal Copernicus style markers.

8.5. Conclusion of quantitative comparison

Let us estimate validity of the null-hypothesis, i.e., all deviations being due to chance. The upper bound for probability of the style markers selected by us occurring simultaneously is the product of the corresponding values: $p_0 \leq p_{quidem} * p_{tunc} * p_{hic} * CUB_{sed\text{-}autem} * CUB_{ergo\text{-}igitur} = 0.000016 * 0.000427 * 0.007699 * 0.194 * 0.077 \approx 7.86 * 10^{-13}$, so it is vanishingly small.[138]

Finalizing the quantitative part of this paper, we can claim that it has confirmed the findings of the qualitative research. As mentioned in section 5, many prominent historians in the past noticed semantic differences (primarily in the cosmology and the terms used) between **C** and **R**. These differences have normally been explained by referring to the texts as belonging to different literary genres and/or by pointing to several decades transpiring between these works. However, it does not seem plausible that the subconscious style markers of a mature

[136] *NB*: here and elsewhere a technique called "add-one" or "Laplace smoothing" has been applied for calculation of probabilities to avoid them becoming 0 and 1 sharp.

[137] **CUB** = min (3.75219, 1) = 1.

[138] See tables 7, 8 and 9.

(well in his forties) well-educated person changed so drastically within a span of less than ten years without a substantial reason. Moreover, the modern empirical research in stylochronometry[139] seems to have excluded the possibility of drastic changes in style caused by aging only. It is rather a slow continuous drift that normally takes place. **C** is very different from **R** stylistically and this has to be accounted for. Let us then proceed to the historiographic analysis of this work.

9. C – Sitz im Leben[140]

What kind of circumstances brought **C** to life? With which purpose was it written? What kind of audience was it intended for? The received view is that Copernicus wanted to share the good news of his great scientific discovery with his friends.[141] Our own analysis shall proceed along the already familiar route:

9.1. Qualitative considerations

- Expertise level. Apart from a short introduction, the text requires a thorough knowledge of *Epitoma in Almagestum Ptolemaei* (1496) of Peuerbach & Regiomontanus. From this observation it can be safely concluded that it was intended for fellow astronomers.
- Bernard Wapowski (1475–1535). This lifelong friend of Copernicus, a Kraków cantor and a secretary of the Polish king Sigismund I, was the preferred first recipient of **C**[142] for the following reasons:
  a) He was close[143] to the Kraków professor Maciej of Miechów, who owned **C**[144].
  b) It was he who approached Copernicus to comment on Johannes Werner's book *De motu octauae sphaerae* (1520), which resulted in producing **L**. The copies of this paper have been

[139] See Can, Patton 2004, Forsyth 1999; Hoover 2017; Klaussner, Vogel 2015; Stamou 2008.

[140] This is a term from biblical criticism and it stands for "the context in which a text, or object, has been created, and its function and purpose at that time". See Reid 2009.

[141] See Appendix 1.3.

[142] See the full story in Appendix 1.4.

[143] They were fellow canons in Kraków and even resided in the same house for some time. See L.A. Birkenmajer 1924, p. 204.

[144] See Appendix 1.3 and 1.4.

found in several libraries all over Europe. However, this fact is not clear evidence that it was Wapowski who took the efforts to inform his correspondents about it – there is no direct historical evidence backing this claim.

c) However, from a letter of Bernard Wapowski to Sigismund von Herberstein (15 October 1535), we know that Wapowski actively tried to promote Copernicus's theory. He attached to this letter a copy of Copernicus's astronomical almanac (it is no longer extant) and asked Herberstein to publish it.[145] So, it is probable that Wapowski could also inform his correspondents about **L**.

Nevertheless, there are a number of counter-arguments:

a) Wapowski cooperated with Copernicus in producing the geographic maps.[146] He was also interested in astronomy and astrology, but was his knowledge at the required level? After all, he did approach Copernicus as an expert to comment the book of Johannes Werner.

b) The record in the library of Maciej of Miechów does not mention the author's name. If Wapowski had indeed presented a copy of **C** to him, would he then fail to mention that the author is the former Kraków university student, well-known nephew of the all-powerful Ermland bishop Lukas Watzenrode?

c) Finally and most importantly, Wapowski did not seem to know much about the theory of his friend by 1524, since Copernicus at the very end of **L** states quite unequivocally: "Lastly, what do I myself think about the motion of the sphere of the fixed stars? Since my views are to be stated elsewhere, I deemed it superfluous and improper to extend this communication further here. For it is enough if I satisfy your desire to have my opinion of this little work in compliance with your request."[147] If Wapowski had ever read **C**, the views of Copernicus would have been already known to him and there was no need for them "to be stated elsewhere" to be communicated.

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[145] Biskup 1973, pp. 155–156, nr. 345, and Swerdlow 2012, Appendix, pp. 16–17.

[146] L.A. Birkenmajer 1901.

[147] *Quid demum ipse de motu non errantium stellarum sphaerae semiam, quoniam alio loco destimata sum, superfluum putaui et impertinens hic amplius immorari, cum satis sit, si modo desiderio tuo satisfecerim, vt meam, quod a me exigebas, de isto opusculo habeas sententiam.*

- Oversights and mistakes. We are again indebted to L.A. Birkenmajer[148] who pointed out some oversights in **C**. Noel Swerdlow made a much stronger statement:[149] "The *Commentariolus* also displays a good deal of carelessness and incomplete understanding on Copernicus's part. Examples of that are the precession, the lunar latitude theory, the latitude theory of Venus and Mercury, and the description of the variation of the radius of Mercury's orbit."[150] And then he proceeded to conclude: "These problems suggest that *Commentariolus* was written in haste…"[151] This inference might be correct, but hastes differ. Swerdlow imagined what can be dubbed a "short-term haste": "[**C**] may have been written in a momentary burst of enthusiasm, perhaps immediately upon devising the heliocentric theory".[152] This suggestion is a *non sequitur* for at least two reasons:
  1) Copernicus is known to us as a prudent individual, not susceptible to sudden bursts of enthusiasm.[153]
  2) The methodology and cosmology of **C** are quite complicated.[154] Most likely it was a mental fruit which ripened after at

[148] L.A. Birkenmajer 1900, pp. 204–205. Ludwik Antoni Birkenmajer also proceeded to suggest that Copernicus did not mention **C** in **R** because it contradicted his major work and he was ashamed of it.

[149] Swerdlow 1973, p. 429.

[150] *Pace* Noel M. Swerdlow, the axiological overtones of this passage inevitably bring to mind the infamously sticky image of a "timid canon" by Arthur Koestler (1959). It can therefore be interpreted as a contemporary scientific chauvinism towards Copernicus in general and his **C** in particular. However, Michał Kokowski in his works has convincingly refuted this statement. From a methodological perspective, the critique of **C** is very arrogant and even naïve. Generally speaking, indeed, some minor mistakes and issues do not diminish the value of this work for the history of science at all – see fn. 154.

[151] *Op. cit.*, p. 429.

[152] Swerdlow, Neugebauer 1984, p. 9.

[153] L.A. Birkenmajer 1900, and other *vitae Copernici*.

[154] High-quality methodological thinking is the foundation of *Commentariolus* and *De revolutionibus*. This is the basis of argument for the originality of Copernicus's achievements. Both **C** and **R** have been written by an author who knew all the tools of the hypothetico-deductive method of correspondence-oriented thinking, which is the method of mathematico-physical sciences. This style of thinking was derived from Plato's *Timaeus* and Ptolemy's *Almagest*, it was continued by *via moderna* (Buridanists) and has been systematically developing among adherents of mathematico-physical

least weeks, but most probably months or even years of intense contemplation.

So, it was not a "short-term haste" but rather a "long-term haste" when some change of life is imminent.

Could it be that the stylistic issues pinpointed by us are caused by this haste? This was in fact our starting hypothesis. However, considering the weight of the stylometric evidence, we had to reject it. Copernicus might indeed simply have had no time to apply a rhetorical polish onto his text, leaving semantic mistakes in and florid passages out. However, it can hardly be expected for someone in the "long-term haste" to change the subconscious propensity for using "*quidem*" or preference of using "*autem*" over "*sed*".

- "Instrumentalist" position. Unlike **R**, **C** does not really try to convince the readers of the truth of the heliocentric hypothesis

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sciences to the present day – see Kokowski 1996; 2001; 2004; 2006; 2009a; 2012b, and fn. 5 above. This fundamental aspect of Copernicus's thought was overlooked by different kinds of Copernican researchers, including, among others, Leopold Prowe, Franz Hipler, Maximillian Curtze, Ignacy Polkowski, Ludwik Antoni Birkenmajer, Pierre Duhem, Ernst Zinner, Jeremi Wasiutyński, Edward Rosen, Alexander Koyré, Kristian Peder Moesgaard, Marian Biskup, Jerzy Dobrzycki, Mieczysław Markowski, Karl R. Popper, Thomas S. Kuhn, Norwood R. Hanson, Imre Lakatos, Alan Musgrave, Elie Zahar, Michael Heildelberger, Larry Laudan, Martin V. Curd, Clarc Glymour, and Ernan McMullin, Nicholas Jardine, Alistar C. Crombie, Edward Grant, Owen Gingerich, Otto Neugebauer, Noel M. Swerdlow, George Saliba, Peter Barker, Bernard R. Goldstein, André Goddu, Pietro D. Omodeo, Stefan Kirschner, and Andreas Kühne. This idea was, perhaps, perceived relatively easily by Kristian Peder Moesgaard (he cited in his works very important quotations from **R** about the correspondence of astronomical models, and accepted the idea in his review of Kokowski's monograph, see Moesgaard 2006) or by Otto Neugebauer and Noel M. Swerdlow (since they together analyzed the mathematical details of Copernicus's astronomy), however these authors were not interested in the methodology of mathematico-physical sciences – see the works of these authors listed in bibliography.

R and **C** describe two different theories – cf. L.A. Birkenmajer 1900, pp. 70–88; 1924, pp. 199–224; Swerdlow 1973; Swerdlow, Neugebauer 1984. It is a crucial point for understanding Copernicus's achievements that the relationship linking these two theories is analogous to the relationship between the General Theory of Relativity and the Special Theory of Relativity or Quantum Mechanics and Classical Mechanics: all these pairs of theories are linked by correspondence principles of Niels Bohr's type; moreover the same type of relation links Copernicus's theory and Ptolemy's one – see Kokowski 1996; 2001; 2004; 2009a, 2012b.

rhetorically while this seems to be of primary concern if the paper was intended for the amateurs. What Copernicus defends instead,[155] expressed symbolically, is:

> Postulate_1 & Postulate_2 & … & Postulate_7 → geokinetic cosmology of 34 circles without equant.[156]

The antecedent of this implication – the 7 postulates – does not need to be correct, to make the whole proposition logically true. This "instrumentalist" stance is especially strange in the light of Copernicus being portrayed as a staunch realist, in sharp contrast to the view of the infamous preface of Andreas Osiander (1498–1552) to **R**. There are indeed plenty of passages in **R** that show that Copernicus genuinely believed in the physical reality of his hypothesis. What can explain his attitude in **C** then? The following seem to be the most plausible guesses:

1) Still in his university years in Kraków, Copernicus was greatly influenced by the *via moderna* of Jean Buridan and his nominalist followers; these ideas were often[157] bundled with the "instrumentalist'" approach to *scientia*.
2) **C** was intended to be read by someone with strongly nominalist beliefs. Marco Beneventano[158] is a distinct possibility.
3) Copernicus at that time was truly not so certain of the truth of his theory. One of the purposes (perhaps, *the* purpose) of writing **C** was to get the opinions of some authorities in the field.
4) A logical conjunction combining the factors 1–3 is, of course, also not excluded.

From the above-mentioned guesses the first is, actually, the least probable. After all, Copernicus's typically realist attitude against the equant is expressed in the very beginning of **C**. In that he followed the opinion

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[155] At least in the introductory part of the paper.

[156] He must have been proud to improve on some other equant-free cosmologies such as Aristotle's 55 homocentric spheres described in *Metaphysics*, Book 12, section 1074a. For a "comparison of the simplicity of Copernicus's, Ptolemy's and Aristotle's theories" see Kokowski 2009a, pp. 170–174, 446–448. Regarding the removal of equants by Copernicus, see Kokowski 2004, pp. 66–67, 75–77.

[157] Grant 1962.

[158] L.A. Birkenmajer 1901.

of his teachers in Kraków university John of Głogów and Albertus of Brudzewo[159] who preferred epicycles/eccentrics to homocentric models but still strived to improve Claudius Ptolemy who "made the planet appear to move at all times with uniform velocity neither on its deferent sphere nor about its own center"[160]. To recapitulate – **C** was not aimed at amateurs at all. Most probably Copernicus wanted to check whether it was possible to build an astronomical theory under the assumption of a moving Earth and a stationary Sun with the fixed stars. Conformity of the predictions of the model presented in **C** with astronomical phenomena (as described by the Ptolemy's *Almagest* / Alfonsine tables) and the removal of the contradictions of these theories (such as the equant) testified for him the realistic truth of his seven postulates.[161]

A stylometric method might help us choose the best hypothesis once more.

9.2. Quantitative research

Recent studies in social psychology backed by experimental research have made it possible to, quite reliably, recover author profile information from their texts.[162] It also involves counting of subconsciously used function words and especially pronouns[163] and is able to get an insight not only into the static variables, such as age, gender or occupation but also take momentary snapshots of the author's psychological state at the moment of writing. For our purposes, the most relevant variable is so-called 'Clout' – which is intended to reflect the author's relationship to the intended reader.[164] It appears that the people perceiving themselves

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[159] L.A. Birkenmajer 1924, pp. 83–134.

[160] Copernicus 1985 (translation and commentary by Edward Rosen), p. 81.

[161] L.A. Birkenmajer overlooked this aspect and had a misconception about the value of *Commentariolus*, as he believed that after discovering in 1515 the variability of planetary apsides and eccentricities as well as the variability of the inclination of the ecliptic to the equator *etc.* (the issues included in the mature theory of Copernicus presented in *De revolutionibus*) Copernicus must have been ashamed of his early work – see L.A. Birkenmajer 1900, pp. 70–88; 1924, pp. 214–219.

[162] A good popular introduction book is Pennebaker 2011.

[163] However, it is more collective counting of certain group of words rather than dealing with the individual **MFW**s.

[164] Formally, 'Clout' = 50 + $(F_{we} + F_{you} + F_{social} - F_{I} - F_{negate} - F_{differ} - F_{swear})$*W, where Fs are the frequencies of the corresponding word category and W – an empirically determined weight factor. The 'Clout' variable ranges from 0 to 100.

standing higher in the social hierarchy ("bosses") tend to use "we" and "you" pronouns (such as "we", "you", "our", "yours" etc.) and so-called "social" words (such as "they", "them", "together", "explain" etc.) more often while they are less likely to utilize "I" pronouns (such as "I", "me", "my" etc.), "negate" (such as "no", "nor", "neither" etc.), "differ" (such as "but", "nevertheless", "however", "although" etc.) and "swear" words. This picture is reversed for the "employees". The rationale behind this "law" might be that the "employees" normally report about their achievements and the "bosses" evaluate them and give directions. In any case, this formula was validated by the empirical research of contemporary languages[165] and resulted in the development of a commercially available software called LIWC[166].

To apply this methodology to our studies we have to overcome the limitation of having no adequate **NLP** for the Latin language. Fortunately, this approach is more semantic-based than the traditional stylometry and has been recently shown to be invariant to translation.[167] Therefore, we proceeded by using the English texts.[168] The results are shown below:

Table 10.

LIWC2015

File Options Dictionary Help

Source texts (7 files) ×

Filename	Segment	WC	Clout	i	we	you	negate	social	differ	swear
1. C+R+L+M English.txt	1	30883	43.07	0.79	0.49	0.08	0.99	3.22	3.73	0.02
2. R body English.txt	1	18624	43.40	0.45	0.53	0.03	0.90	2.77	3.61	0.03
2. R Dedication letter Englis...	1	2072	33.20	4.01	0.14	0.48	1.79	5.79	4.97	0.00
3. C body English.txt	1	4450	41.39	0.34	0.13	0.00	0.61	2.02	3.39	0.00
4. C intro English.txt	1	698	35.46	1.72	0.72	0.00	2.01	3.58	4.30	0.00
5. L English.txt	1	3308	54.92	1.24	1.09	0.30	1.18	5.74	3.48	0.00
6. M English.txt	1	1731	37.10	0.58	0.06	0.00	1.21	3.00	4.56	0.00

[165] Kacewicz et al. 2014.

[166] Pennebaker et al 2015a; Pennebaker et al 2015b.

[167] Meier et al. 2021. It can be argued that more studies are required to confirm this finding especially in connection with the Renaissance Latin texts.

[168] Again, we used the translations found at online resources such as http://copernicus.torun.pl/en/archives.

Please, note the following:

- **WC** means "Word Count", the texts were not divided (Segment value is 1), the other columns show corresponding values for the integral style marker 'Clout' and its constituents.
- We placed the introductory parts of **C** and **R** (the dedication letter to the Pope) into separate files since their content differs sharply from the scientific rest of the text.
- The 'Clout' variable in LIWC ranges from 0–100. The relatively low 'Clout' rating range of Copernicus writings can be explained by the fact that the modern software does not expect or misinterprets the words and expressions of 16th century learned scholars[169].
- However, even then the standard deviation for the whole Copernicus corpus is 6.32,[170] which means that the 'Clout' value of 'C intro'[171] (*sc.* 35.46, see Table 10) is at more than one-sigma distance (*sc.* z-score = –1.20) from the average (*sc.* 43.07–6.32 = 36.75 > 35.40). It is not statistically significant under the assumption of the normal distribution for the p-value < 0.05 but has a considerable persuasive force for the purposes of our historical investigation, since the probability of null-hypothesis (stating that the deviation of **C** is due to chance) being true is less than around 0.23 (which is the two-tailed p-value).
- Predictably, the Dedication letter of **R** addressed to the highest church authority had the lowest 'Clout' rating (*sc.* 33.2, see Table 10) which makes its z-score equal to –1.56 and the two-tailed p-value to be around 0.12.
- No less predictable is the highest 'Clout' rating (*sc.* 54.92, see Table 10) of **L** which was addressed to Bernard Wapowski who asked for Copernicus's expert advice. Its z-score is 1.88 and the two-tailed p-value around 0.06.

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[169] E.g. it categorizes "father" in "most holy father" as a social word increasing the 'Clout' value while it should do exactly the opposite. Furthermore, a whole range of the rating is allocated to swear words which have never been used by the learned scholars of the 16th century (curiously, 'AF' in a geometrical context becomes a swear word). And, of course, it is also not able to detect such subtleties as sarcasm of **L** which we mentioned in section 6.1 point 3.

[170] The standard deviation has been calculated by dividing the whole text ('**C**+**R**+**L**+**M**') into 10 segments.

[171] This is the text from the very beginning of **C** till *De ordine orbium*.

- It is worth noting the close proximity of the 'Clout' ratings of '**C** intro' and the Dedication letter of **R**.
- The dry scientific texts and the grand average of all texts are all located in the "grey" area of 40–44 points.

9.3. Conclusion: Sitz im Leben of C

The above-mentioned evidence allows us to draw the sought conclusion about the *Sitz im Leben* of **C** – it seems not to be intended to be read by friends after all.[172] Rather, it was directed to some people of authority for Copernicus, probably acquainted astronomers. The plausible reason for writing it was to get their opinion on his idea. Who could be these people? We can probably safely exclude not only Bernard Wapowski but also other friends from Kraków, such as Marcin Biem (ca. 1470–1540), Mikołaj of Szadek (1489–1564) or Mikołaj of Wieliczka (ca. 1490––1559) since they were of similar age or younger than Copernicus and he could hardly write to them with such a low 'Clout'. But these could be one or more professionals mentioned below:

a) In Italy:
   - His own *praeceptor* Domenico Maria Novara (1454 – 1 August 1504).
   - Marco Beneventano (c. 1465 – c. 1525) who was considered an expert in the cosmological models of the 8th sphere.[173]
   - Paul of Middelburg (1446–1534). This is perhaps the most plausible guess,[174] which allows to explain his invitation to participate in the church calendar reform that Copernicus received, and the subsequent reference to him and the exact match of the tropical year length in Paul's writings.[175]

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[172] We know from the early biography of Copernicus – Starowolski 1627 – that Copernicus corresponded with his friends, Kraków astronomers, but it would be a hasty conclusion to identify this communication with sharing of **C** with them.

[173] See L.A. Birkenmajer 1901.

[174] The very first Copernicus biography (dated 1588) by Bernardino Baldi (1553––1617) claimed that already during his university years in Italy he was on friendly terms with Paul of Middelburg, who was then in the service of Guidobaldo I (1472––1508), the duke of Urbino. See Biliński 1973.

[175] L.A. Birkenmajer 1924, pp. 225–231, 378–382; Biskup 1973, p. 67, nr. 103; and Appendix 2.

b) In Kraków:
   - The old professor John of Głogów (c. 1445–1507) seems to be a very suitable addressee.[176]
   - Another interesting possibility is Simon of Sierpc (d. 1512), the student of John of Głogów, who used *Commentariolum* of Albertus de Brudzewo[177] to teach Copernicus.

     Notice: John died in 1507 and Simon in 1512, which is a suitable timing for **C** to get into the library of Maciej of Miechów as part of their inheritance.[178] This kind of provenance would explain that **C** lost attribution to its author.

c) In Nuremberg, Germany:
   - The successor of Regiomontanus Bernhard Walther / *Bernardus Gualterus* (1430 – 19 June 1504) was old but still alive in 1503–1504, he collaborated with Domenico Maria Novara in Bologna, and Copernicus might have known him.[179] It is also peculiar that a close friend and teacher of Rheticus, Achilles Pirmin Gasser, mentioned in a handwritten note of his copy of **R**[180] that Copernicus observed Mercurius in Nuremberg (presumably in company of Walther) on March 18 of 1504:

> Anno 1504 die 18 Martii observavit Copernicus cursum ☿ (sic, i.e. Mercurii), et ab observatione hac 21 anno Ptolemaei Philadelphici Regis Aegyptiae (sic) usque ad praesentem elapsos esse scribit annos 1768 Aegyptiacos dies 200, 33', quae efficiunt Julianiacos 1767, dies 123, 33' Cop. lib. 7 (sic) c. 30. Hic nonnulli annum unum abundare volunt ut et

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[176] L.A. Birkenmajer 1924, pp. 103–134.

[177] L.A. Birkenmajer 1924, p. 96.

[178] The books in Kraków university often passed from the hands of the old professors to their successors: "*alter alteri per manus tradat*". See L.A. Birkenmajer 1924, p. 218, fn. 2.

[179] L.A. Birkenmajer 1900, pp. 303, 446; Zinner 1943 / 1988, p. 166; Beaver 1970, p. 42 – "although it is only a matter of conjecture".

[180] *Editio princeps* of 1543, which he received as a gift from Johannes Petreius, currently in the Vatican library bearing the shelf marks Stamp.Pal.III.103(int.1) and Stamp.Ross.3759, see https://opac.vatlib.it/stp/detail/10114163.

> in reliquis observationibus. Vide Chronol. Gerardi Mercatoris.[181]

Dr. of medicine Achilles Gasser mentions many correct details and is known (apart from being one of the first Copernicans) as an author of excellent concise books including historical works.[182] However, we can agree with L.A. Birkenmajer that the major problem with this evidence is that it contradicts Copernicus himself, who attributed this very observation to Schöner.[183] Besides, this notice was written after 1569 (i.e. more than 25 years after the publication of **R**) since it refers to *Chronologia* of Mercator and the focus of Gasser must have been on the Copernican calculation of the elapsed time rather than on his presence in Nuremberg.

According to L.A. Birkenmajer the three modern observations of Mercury that are used in **R** (l.5, c.30) reached Copernicus via Johannes Dantiscus, who corresponded with a well-known humanist, an excellent poet and stylist, Helius Eobanus Hessus (1448–1540). He, though no astronomer, being the rector of the Nuremberg *gymnasium*, had access to the observations of Regiomontanus and Walther in 1526–1533. It was likely that Hessus copied the data of these three observations of Mercury in an imprecise way. Therefore, Copernicus changed the details of some of them three times in the autograph of **R**.[184] However, according to Ernst Zinner (1938, p. 173 / 1968, p. 231): "Copernicus had three determinations of Mercury's position [mentioned in **R**] reported to him by Schöner." Zinner repeated the opinion in his next monograph (Zinner 1943 / 1988, pp. 212, 214).-Edward Rosen had serious doubts about that – due to lack of historical sources – and thought that Copernicus had received them from Rheticus

[181] Müller 1898, p. 4, fn. 3; L.A. Birkenmajer 1900, p. 302*ff.* quoted Müller (slightly abridged).

[182] Burmeister 1970.

[183] Also mistakenly, since according to Johannes Schöner (1544, p. 60) it was made by Walther.

[184] L.A. Birkenmajer 1900, pp. 303–306.

in 1539 only, who in turn had received them from Schöner before Rheticus's trip to Warmia[185].

- Johannes Schöner (1477–1547), who published the works of Regiomontanus and Walther is the other, though less likely, possibility.[186]

  Johannes Schöner is sometimes claimed by historians to be the person who encouraged Rheticus to visit Copernicus in Prussia in 1538.[187] This belief is mainly based upon Rheticus dedicating *Narratio prima* to him. However, consider the following:

  1) Back in 1533, Johannes Schöner published in his *Opusculum geographicum* … a small chapter called *An terra moveatur an quiescat, Joannis de Monte regio disputatio*[188] "proving" the immobility of Earth as part of Regiomontanus-Walther library inherited by him from his *Maecenas* Willibald Pirckheimer (5 December 1470 – 22 December 1530). It is a strange publication for two reasons. Stylistically it does not resemble other Regiomontanus texts known to us.[189] Secondly, it does not contain any original arguments, barely deviating from the well-known banalities of the university text books, based on the Aristotelian-medieval physics. So, it seems that Schöner's goal was to use the authority of Regiomontanus to confirm his own point of view. Indeed, as far as we know, he never expressed publicly any

[185] Copernicus 1978, pp. 433–434.

[186] Schöner resided in 1503–1504 in Hallstadt near Bamberg (around 65 km from Nuremberg by modern roads) serving as a chaplain. There are no connections between him and the famous Nuremberg mathematicians, which can be traced from the extant documents. However, his diary, handwritten on the margins of *Regiomontanus Ephemeris* for the years 1475–1507 (sign. Ink.4.H.7 of the Österreichischen Nationalbibliothek) used to belong to Bernard Walther – see Maruska 2008, pp. 16–17, 170–194; Appendix 2, and section 12 below.

[187] E.g. see Prowe 1883–1884, vol. I, part. 2, pp. 391–392; Burmeister 1967–1968, p. 37.

[188] See Schöner 1533, Pars 1, cap. 2; Omodeo 2014, pp. 19–20; Bardi, Omodeo 2021.

[189] Some historians suggested that the true author was Georg von Peuerbach (May 30, 1423 – April 8, 1461) – see Zinner 1943/1988, p.100, and Grössing 1983, p. 91, or even Johannes Schöner himself – see Regiomontani, Schmeidler 1949, p. XIII. However, Pietro Daniel Omodeo and Alberto Bardi do not doubt Regiomontanus's authorship – see: Omodeo 2014, pp. 19–20; Bardi, Omodeo 2021.

opinion on Copernicus at all. In fact, he is known to consistently hold quite traditional, conservative beliefs and the silence has been his typical attitude towards the relationships he did not like.[190]

Notice: provided he had truly wished to get acquainted with Copernicus's theory, Schöner did not need Rheticus for this purpose at all. He might easily use the connections of Andreas Osiander instead, who converted the duke of Prussia Albrecht (1490–1568) to Lutheranism.

2) Rheticus in 1538–1539 was not an overenthusiastic shapeless youth whom Copernicus and Schöner molded as they wished, which is how he is sometimes portrayed. He was rather a smart, highly rhetorically-skilled individual with a clear agenda.[191] Many historians believed that Copernicus gave so-called "astronomy lectures" in Rome before Ryszard Gansiniec (1957) showed that the confusion was caused by a deliberate "honest lie" of Rheticus. Trying to portray Copernicus as a new Ptolemaeus, he called him "professor". However, the text never says that Copernicus "lectured" (*docuit*) in Rome. While it is probably true that Copernicus gave some private lessons[192] and conducted some astronomical observations *in Urbe* (e.g. the lunar eclipse of November 5/6, 1500), Rheticus most probably let the reader mentally imagine "lectures" as a consequence of this "professorship". It seems that in a very similar fashion he "made" Schöner send him on a scientific mission to Prussia, i.e. by a clever choice of the word "*fama*", which can be translated both as "report" and as "rumour".[193] Why would he do that? Most probably because he needed to link the famous name of Schöner with his book – towards both Copernicus and his own German

[190] E.g. this was his stance towards the Augsburg Benedictine monk Veit Bild (1481–1529) – see Maruska 2008, pp. 28–32.

[191] See Kraai 2001, pp. 75–86.

[192] To a certain Pietro Romanelli – see Biliński 1973, p. 19.

[193] "*Pridie Idus Maias ad te Posnaniae dedi literas, quibus te de suscepta mea profectione in Prussiam certiorem feci, et significaturum me quam primum possem,* ***famaene*** *et meae exspectationi responderet eventus, promisi*" (Rheticus 1540 / 2009, p. 2).

connections.[194] *NB:* Johannes Petreius (c. 1497 – March 18, 1550) in his letter to Rheticus (dd. 1st August 1540)[195] merely mentions his discussions ("*conferres*") with Schöner.

3) How would Rheticus then come to the idea of visiting Copernicus? One possibility is his communication with Georg Hartmann (1489 – April 9, 1564), who settled in Nuremberg in 1518, and knew the brother of Nicolaus Copernicus – Andreas.[196]

   The Nuremberg publisher Johannes Petreius also could have heard about the achievements of Copernicus through his contacts, e.g. with the celebrated Italian astrologer-astronomer Luca Gaurico (1475–1558), whose works he began to publish in 1540.[197] He also had a clear business incentive to maintain his reputation as the leading publisher of the valuable mathematical (astronomy was considered the pinnacle of mathematical quadrivium) books. However, his aforementioned letter of the 1st August 1540[189] to Rheticus contains no hints on him being interested in Copernicus's theory back in 1538 – it is rather a late recognition of commercial value of the work announced in *Narratio prima*.

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[194] It is noteworthy that *Narratio prima* was given the form of an open letter from a "certain young student of mathematics", i.e. an anonymous disciple of both Copernicus and Schöner. Perhaps, this was a deliberate attempt by Rheticus to place himself in the shadow of the great men rather than merely an expression of humility, as Karl Heinz Burmeister thought (1967–1968, vol.1, p. 46). However this so-called humility expired very soon, since already the Basel edition (1541) of *Narratio prima* explicitly referred to Rheticus as its author; apparently by this time he had already reached his goals. What might have been his true intentions? In this way Rheticus could deceive Copernicus that his works were valued by the famous Schöner, persuading him to publish **R,** and appear to the Wittenberg university officials to be on an important mission rather than on an expensive leisure tour.

[195] Burmeister 1967–1968, vol. 3, pp. 19–21.

[196] See Kraai 2001, pp. 80–81; Wasiutyński 2003, pp. 336–337.

[197] "Although there is no apparent connection between the circle of Clement VII and Nuremberg (then a Protestant city), there is a direct connection between the Nuremberg publisher Petreius and one of Clement's successors, Paul III (d. 1549), in the person of the celebrated astrologer and astronomer Luca Gaurico (d. 1558)" (Barker, Goldstein 2003, p. 349). See Appendix 2.

Another guess is the presence of **C** among Regiomontanus-Walther papers in Nuremberg.[198] We know that Schöner provided access to them to Rheticus.[199] Finding **C** inside these papers would be the easiest way to explain its possession by Rheticus, his decision to visit Copernicus and the willingness of the Wittenberg university officials to bear his prolonged absence and finance the journey.[200] On the other hand, Rheticus himself mentioned neither **C** nor **L** in his publications and letters.[201]

The key to this enigma is, perhaps, the motivation of Rheticus to undertake the long and costly journey to Warmia. First of all, he loyally belonged to the so-called "Melanchthon circle" in Wittenberg and the rest of Germany. The scholars of this circle strongly believed in the high value of astrology as a solution for a wide range of issues – from meteorology to eschatology.[202] Quite naturally, Rheticus, being an advocate of astrology,[203] was interested in the revision

[198] According to Jesse Kraai "It was through Copernicus'[s] critique of Werner's work, the *Letter against Werner*, that the Nuremberg circle would have first discovered Copernicus" (Kraai 2001, p. 80). **L** indeed could have been available in Nuremberg. However, there is no evidence to support this claim. **L** taken **alone** would be unlikely to excite Rheticus so much to undertake the journey to Copernucus. So, this paper is less relevant for the current discussion.

As for **C**, according to Peter Barker and Bernard R. Goldstein "there is no evidence that this work was available in Wittenberg before Rheticus's departure in 1538, or in any of the places he visited. Later Wittenberg astronomers owned and annotated *De revolutionibus*, but the earliest indications of their knowledge of Copernicus appear after the publication of the *Narratio prima* in 1540" (Barker, Goldstein 2003, p. 348). There is indeed no direct evidence of availability of **C** in Nuremberg before 1538 but we cannot exclude the possibility that the local scholars knew of the paper, finding it not worthy of the discussion at the same time.

[199] See the letter of Philipp Melanchthon (16 February 1497 – 19 April 1560) to Erasmus Ebner (21 December 1511 – 24 November 1577) dd. 7 July 1542, see Burmeister 1967–1968, vol. 2, page 46, nr. 12.

[200] See section 12 below.

[201] L.A. Birkenmajer 1900, pp. 582–621; 1924, pp. 356–378.

[202] See Westman 1975b–1975e; Brosseder 2004.

[203] It is first of all evidenced by his own astrological passage in *Narratio prima*. See also Kremer 2006; Green 2010; Kirschner, Kühne 2015 and Rosen 1939 (2nd ed. 1959, 3rd ed. 1971) for the English translation of *Narratio prima*. However, the thesis

of astronomy – in more recent accurate observations and more adequate theories – and therefore he wanted to visit Copernicus, who was treated at the time as one of the greatest experts in this field.[204] Moreover, Rheticus's personal traits involving consistent arduous search for the "luminaries" of the time also should not be underestimated.[205]

However, it seems that it was an ugly scandal in Wittenberg[206] that forced Melanchthon to send Rheticus on the knowledge acquisition trip. Apparently, the best way to keep the wrath of infuriated Luther towards Rheticus at bay was to keep the young professor away for some time. It is then very natural to suggest that Rheticus passionately desired to recoup his position. The ideal scenario for him was to return triumphantly as a discoverer of the second Ptolemaeus. At this point it is important to realize how

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of Robert Westman that this passage had been approved by Copernicus and that the whole theory of the moving Earth arose out of Copernicus's astrological interests has no empirical (source) justification, see L.A. Birkenmajer 1924, pp. 56–60; Kokowski 2009, pp. 50–52; Westman 2011; 2013a; 2013b; Swerdlow 2012; Heilbron 2012. Nevertheless, it is probably true that the astrological interests of the "Melanchthon circle" drew the arcane work of Copernicus into the light of publicity.

[204] Since Copernicus's theory was based on observations from ancient times to his own, and predicted past and future configurations of planets and stars, it was intended as a kind of universal history of astronomical phenomena – see Kokowski 1996; 2004; 2006a. That is why his contemporaries called him "the divine thinker", "the second Ptolemy", "the new Ptolemy", "the restorer of astronomy", "the renovator of astronomy", etc. – see Kokowski 2009, p. 46, pp. 275–279, fn.14–23. Only later did it turn out – thanks to, among others, Tycho Brahe and Johannes Kepler – that the observations at Copernicus's disposal were imprecise and the models of astronomical phenomena postulated by Copernicus should be rejected.

[205] Kraai 2001, pp. 43–44: "The belief that God illuminated certain men structured to a large extent Rheticus'[s] entire life. He continuously sought the "luminaries" of his time and marked their words as Gospel. This belief formed to a certain extent the backdrop of his trip to Nuremberg, Ingolstadt and Tübingen in 1538. Above all however Rheticus would later reflect upon the personages of Copernicus, Cardano, and Paracelsus (whom he met at the age of 18 and later vigorously studied)…"

[206] Op. cit. p. 65: "A more comprehensive account of Rheticus's absence from Wittenberg lies in the terrible scandal of Rheticus's friend Simon Lemnius, a scandal that came close to permanently dividing the most powerful figures of the Reformation in Wittenberg."

much was at stake for Rheticus. Let's suppose that he returned from Prussia empty-handed. This would incur even more costs to the university and would cause his reputation to suffer further. It is hard to imagine Rheticus being so reckless as to gamble without calculating the risks first. It is therefore equally unimaginable for Rheticus to go to Copernicus having based his decision on the vague rumors only. He should have had something more substantial than that and it could only be something like the elusive **C**.

10. Dating C

Based on the conclusions reached above, let us try to determine the composition date of **C.**

10.1. Qualitative considerations

The more or less hard facts that restrict our speculation space are:

1) *Terminus post quem* – since **C** depends on **GV** (i.e. Georgio Valla's *De expetendis et fugiendis rebus*)[207] as one of its sources, it can be safely dated after its publication year (1501).
2) *Terminus post quem* – since **C** depends on *Almanach perpetuum* by the Jewish astronomer Abraham Zacut of Salamanca edited by Alphonsus de Cordoba called Hispalensis, as one of its sources (it refers to the value of the tropical year assumed in this *Almanach*), it can be safely dated after its publication in Venice on 15th July 1502.[208]
3) *Terminus post quem* – 1509 was suggested by Edward Rosen, who noticed that Laurentius Corvinus's poem entitled *Farewell of Prussia*, being an introduction to Copernicus's translation of Theophylactus Simocatta and published in 1509 in Kraków, mentions the "alternating movements" of Copernicus's Sun. Thus, it seems to suggest that by that time the new cosmology had still not been discovered, since the Sun in **C** is motionless.[209]

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[207] L.A. Birkenmajer 1924, p. 165.

[208] L.A. Birkenmajer 1924, pp. 352–355; A. Birkenmajer 1933, p. 6; Wasiutyński 2003, p. 332.

[209] See Rosen's comments in Copernicus 1985, pp. 79–80, and Appendix 1.3.

However, this evidence is quite dubious at the very least. In the same verses Corvinus praises the "wonderful principles"[210] that allowed Copernicus to explain these movements. These principles could refer to the new theory of Copernicus. Curiously, these words have been used by many historians[211] to prove exactly the opposite – 1509 as *terminus ante quem*.

To conclude, the poetry has its own laws[212] and we cannot rely on his internally contradictory evidence. So, it seems that 1509 should be rejected both as *terminus post quem* and as *terminus ante quem*.

4) *Terminus ante quem* – 1 of May 1514 comes from the date of "*Item sexternus Theorice asserentis Terram moveri, Solem vero quiescere*" listed in the library catalog of Maciej of Miechów[213].

Even earlier dating of **C** (1503–1504) can be argued here on the basis of the following considerations:

1) A profound style change. The style markers that changed so drastically (from **C** to **L/M/R**) could only be a result of long-time dedicated efforts, the study resulting in a steep learning curve. In fact, we know for certain of the one and only period in Copernicus's life after 1501 when he was busy improving his rhetorical skills. That was during his stay at the Heilsberg (Lidzbark) castle with his uncle in 1504–1509. Not only did he translate into Latin the Greek verses of Theophylactus Simocatta during this time, but most probably assisted the bishop as a secretary as well.
2) "Long-term haste." Copernicus did not experience many profound changes in his life.[214] One of them came at the time when

[210] *miris … principijs*.

[211] See the full story in Appendix 1.3.

[212] In fact, the "*miris … principijs"* might be an allusion to the famous verse of Virgil "*Felix, qui potuit rerum cognoscere causas*" from Georgics (l.2, 490); the Moon being a brother of the Sun can be found in the same poem (l.1, 395): "*Nec fratris radiis obnoxia surgit Luna*" and the "alternating movements" could express a banality that the Moon is normally visible during the night and the Sun during the day. In other words, Corvinus probably simply wanted to praise Copernicus for his astronomical pursuits and nothing more than that.

[213] See L.A. Birkenmajer 1924, pp. 200–224; Hajdukiewicz 1960, p. 384, and Appendix 1.3. The actual discoverer of this record was Adam Chmiel, director of the Archiwum Akta Dawnych Miasta Krakowa [Archives of Historical Records of the City of Kraków] – it was L.A. Birkenmajer himself (1924, pp. 200–201, fn. 3) who emphasized this fact.

[214] At least in 1504–1509, he experienced no drastic changes at all.

he received a doctorate degree in canon law and finished his university studies. He knew very well from past experience what kind of life was waiting for him back in Heilsberg (now Lidzbark Warmiński) of Polish Prussia at the side of his uncle Lukas Watzenrode. The bishop castle's construction and formal prohibitions made any astronomical observations impossible. There were no books on mathematics and astronomy in the library but many classic Latin authors's writings.[215] Hence, Copernicus in Heilsberg had to rely on his own library, collected during his university studies in Kraków (1491–1495) and Italy (Bologna, Padua, Ferrara and Rome in 1496–1503). Knowing that his cosmological views would not escape criticism, he had to rush to get at least some authoritative opinions on his new ideas.

3) It is well known that Copernicus changed his handwriting style from so-called "Gothic script" to "humanist calligraphy".[216] As late as 1503, he still used his "15th century" style in a notarial document issued in Padua, Italy.[217] It seems plausible to suggest that the changes of handwriting and writing styles coincided in the same period of his life.
4) Intended readers. If the given above conclusions about *Sitz im Leben* of **C** are correct, Copernicus wrote this paper for the astronomers who were his authorities in this field of knowledge. The obvious choices are his Italian acquaintances, Kraków professors and, perhaps, some Nuremberg connections.[218] It was much easier to hand over the manuscript personally rather than to use courier services afterwards.
5) The record in the library of Maciej of Miechów does not mention the name of the author of "sexternus Theorice". We should allow some substantial time to elapse for the paper to lose attribution to the well-known nephew of the mighty bishop of Ermland.

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[215] See Brachvogel 1928; Górski 1973b, p. 120.

[216] See Rosińska 2001.

[217] See Biskup 1973, p. 44, nr. 42.

[218] To return to Prussia from Padua he might have chosen the road leading via the Brennerpass to Nuremberg and Rheinland (so-called Via Raetia) rather than via Semmering, Vienna and Kraków. Nuremberg was a kind of astronomical Mecca during Copernicus's times. However, there are no sources supporting this hypothesis.

10.2. Quantitative research

The stylochronometry mentioned above can help to identify those style markers that slowly drift with age. Unfortunately, we could not use **R** to locate them since its composition date is spread over many years and, moreover, remains controversial. However, we could use for these purposes another Copernicus treatise – *Monetae Cudendae Ratio*[219] – whose dating (1526) is quite secure. Investigation of the sequence of texts (**C, M, L, MCR**) allowed us to find 4 relevant style markers. Below are the corresponding graphs:

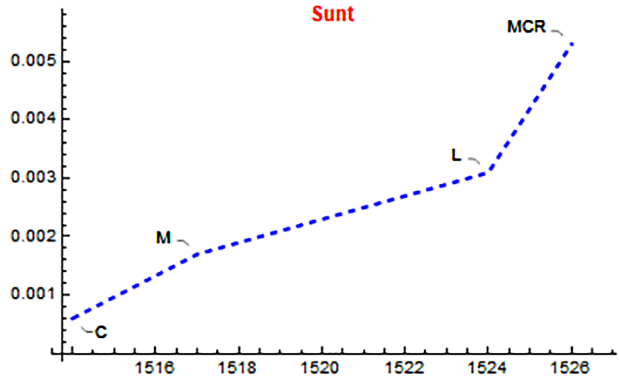

Chart 8.

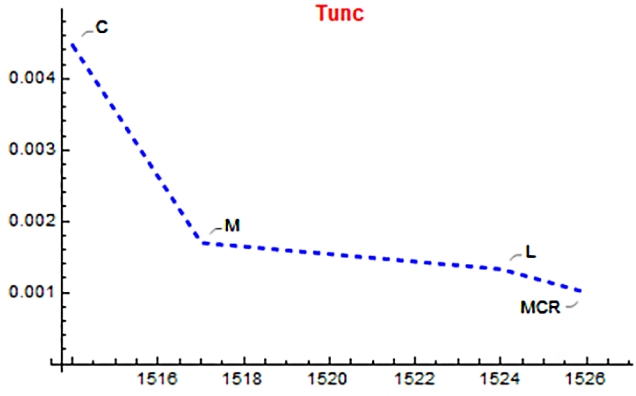

Chart 9.

[219] We called it MCR. For Latin text see Copernicus 2007; for the English translation, see Copernicus 1985, pp. 176–193.

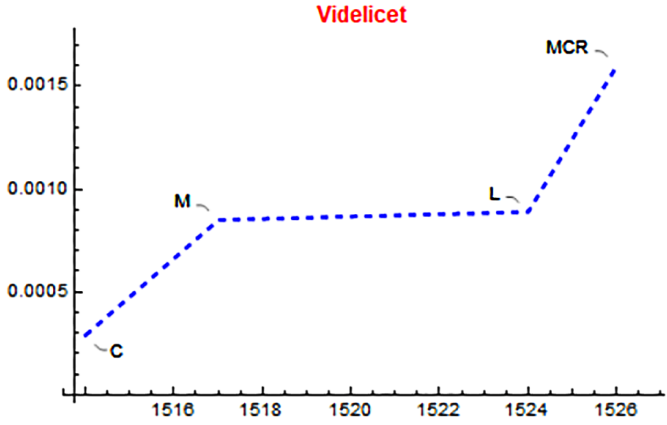

Chart 10.

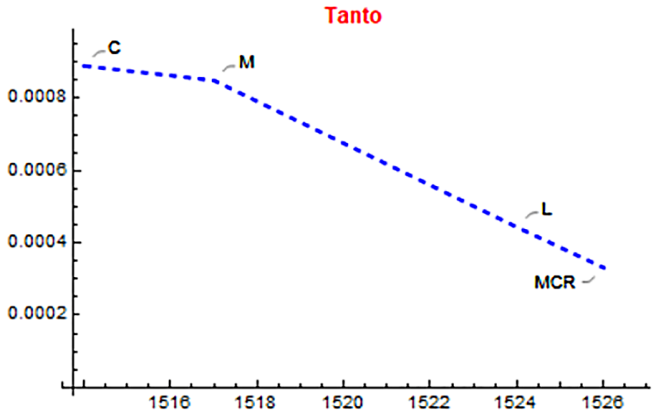

Chart 11.

Note that the extrapolation of the lines of **MCR–L–M** in the past direction in all these 4 graphs leads to the date even earlier than 1503.

10.3. Conclusion: Dating C

The above-mentioned findings allow us to tentatively conclude that **C** had been written much earlier than it was previously thought – 1503––1504 being the most probable dating.

11. Interstylistic travel

So far, we have watched the sharp turn of the Copernicus's literary road after 1503–1504 but how did he get to his peculiar writing style in the first place? In fact, semantic comparison of texts has been a major tool of identification of possible influences on Copernicus at least from the times of L.A. Birkenmajer (1900). We might now try to do exactly the same on a lower, linguistic level if the following postulate were granted to us:

P7: The writing style might sharply change if there is some external influence – from reading books or communication with people.

Accordingly, we have tried to measure the "interstylistic distance" between **A** and **C**. With the only exception of **CC,** these are the texts Copernicus should have been familiar with. The findings are the following:

11.1. Qualitative considerations

PR[220]**:** Peuerbach & Regiomontanus "*Epitoma in Almagestum Ptolemaei* (1496)**.**

Similarities with **C**:

- Some terms: *diametrum, mundus, firmamentum, caelum, sphaera stellarum fixarum, semidiametrum, semicirculus, orbis lunaris.*
- Quite a few *quidem.*

Differences with **C**:

- Clear, easy to follow Latin, classic long sentences, rhetorical figures (anaphora, asyndeta).
- No long *ablativi absoluti.*
- Some other terms: *philosophi* (predecessors)*, planetae, motus (stellarum) circularis, non errantes, (stellarum) circuitio, terra* (instead of *tellus*). Preference for *spherae* over *orbes.*

GV: Georgio Valla *De expetendis et fugiendis rebus* (1501).

Similarities with **C**:

- Structured by headings *De …* (or *Quid considerandum (esse/ est?)*)

Differences with **C**:

- Clear, easy to follow Latin, classic long sentences, typical humanistic use of language, Grecisms, plentiful rhetorical figures (namely anaphora), quotations of classic authors.

[220] These symbols again represent the abbreviations, see section 4.

- No long *ablativi absoluti,* infrequent use of passive voice.
- Some terms: *mathematici, astronomi* (predecessors) *planetae, astrologia.*

AB: Albertus de Brudzewo *Commentariolum super Theoricas novas planetarum Georgia Purbachii* (1482).

Similarities with **C**:

- Enumerations: *uno modo, secundo, tertio modo; pro aliquibus suppositionibus, Prima, Secunda, Tertia, Quarta, Quinta potest addi; tribus motibus, Primo motu, secundo motu, tertio motu.*
- Frequent use of passive voice.
- Some terms: *motus, motus diurnus*, *orbes, orbes coelestes*, *sphaera, coelum, corpus coeleste, stellae fixae.*
- Use of *sicut dictum est, iam a nobis dictum est.*

Differences with **C**:

- No long *ablativi absoluti.*
- No predicative present participles used in simple constructions.
- Some other terms: *coelum stellatum, sphaera stellarum, astra mobilia, planetae; sphaerae coelestes mobiles, terra* (instead of *tellus*). Preference for *sphaera* over *orbis.*

CC: Celio Calcagnini *Opera aliquot* (c. 1525, printed posthumously 1544).

Similarities with **C**:

- Some terms: *sydus (syderis); orbes (suis … orbibus); rotunditas; centrum (centri); (caeli) ambitum*, *tellus.*

Differences with **C**:

- Clear, easy to follow Latin, classic long sentences, typical humanistic use of language, Grecisms, plentiful rhetorical figures (anaphora, asyndeta, rhetorical questions), quotations of classic authors.
- Infrequent use of passive voice.
- Little or no structure: no headings, no enumerations.
- Some other terms: *astra; in medio mundi; stelliferum ambitum, octava sphaera, philosophi* (predecessors).

JG: John of Głogów *Introductorium co[m]pendiosum in Tractatu[m] spere materialis* (1513).

Similarities with **C**:

- The Latin is not smooth and elegant.
- Structure, headings and enumerations: *due sunt, Quarum prima est…, Altera pars… ; Differentias … tres, Primo… , Secunda differentia… Tertia differentia … tribus … causis, primo, Secundo, Tertio; duplex, et alia est; duas, prima, postea. Haec tamen de … sufficit nunc dixisse.*

- Frequent use of passive voice.
- Some names: Caldeus (*cf.* Chaldeus in **C**), Ptholomeus is called *sapiens* (*cf. sapientes* in **C**).
- Some linguistic constructions and terms: *(moventur) sursum … aut deorsum* (in **C**: *sursum et deorsum aspiciuntur*); *terra immobili permanente* (in **C**: *firmamento immobili permanente ac ultimo caelo*), *stellae; caelum, semicirculus, centrum spere, corpora caelestia (de motu, aspectibus et coniunctionibus corporum celestium); mundus.*

Differences with **C**:

- No long *ablativi absoluti.*
- No predicative present participles used in simple constructions.
- Some other linguistic constructions and terms: *in scientia stellarum doctissimi, auctores antiqui, philosophi, phisici* (predecessors), *planetae (scientia de circulis planetarum et orbibus eorum motibus et accidentibus que eorum magnitudo et quantitas), astra (Astrorum disciplina; astra* in the sense of *stellae), motus … circularis (motui intelligendo circulari quo ad speras celestes), caelum stellatum/ octava spera, totum universum, terra* (instead of *tellus*).

MW: *Abstemius* (Mikołaj Wodka of Kwidzyn) – some letters (1464, 1477, 1480, 1485, 1492).

Similarities with **C**:

- Frequent use of passive voice.
- Some names: Ptolomeus.

Differences with **C**:

- The Latin is not smooth and elegant but can be easily followed. Sometimes rhetorical figures are used: anaphora (*nullum… nullum… nullum*) and metaphoras.
- No clear structure and no enumerations.
- Some terms: *stella* in the sense of planet, *solaris* (cf. *solis* in **C**).
- No long *ablativi absoluti.*

MB: *Martini Biem de Olkusz* (Marcin Biem z Olkusza) *Poloni nova calendarii Romani reformatio* (1516).

Similarities with **C**:

- Use of *sicut dictum est.*

Differences with **C**:

- Clear, easy to follow Latin, classic long sentences, typical humanistic use of language, rhetorical figures, citations.

- Infrequent use of passive voice.
- No long *ablativi absoluti*.

11.2. Quantitative research

It seems natural to estimate the interstylistic Proximity of our 7 texts to **C** as a product of upper bounds for the selected by us style markers.[221] We omit the calculation and render the results in the table 11 and the corresponding bar chart 12:

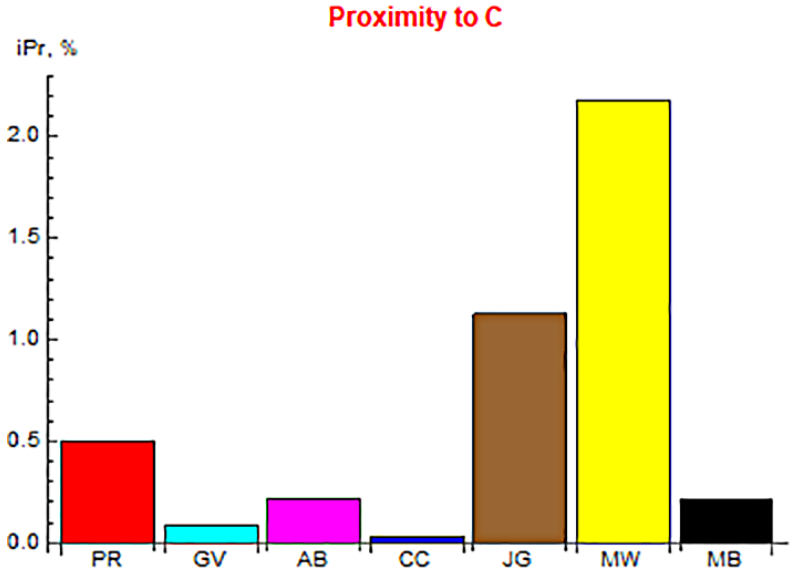

Chart 12.

[221] I.e. 3 **MFW**s and 2 **POS**s. For the MFWs we take the corresponding p-values, for the POSs the **CUB**s. Formally, we define iPr as $p_{quidem} * p_{tunc} * p_{hic} * CUB_{sed\text{-}autem} * CUB_{ergo\text{-}igitur} * 100$. Because the calculated product values were rather small (quite naturally so, since we were comparing texts of different authors), we included an additional factor of 100, so that the interstylistic proximity could be seen as a similarity percentage. Note: A more traditional approach in modern stylometry would be building a proximity graph using the cluster analysis algorithms (e.g. see Eder 2014). We encourage other authors to undertake this type of research. We decided, perhaps incorrectly, that our own simpler proximity estimation would suffice for our purposes.

Table 11.

	PR	GV	AB	CC	JG	MW	MB
p_{quidem}	0.825	0.509	0.708	0.534	0.431	0.431	0.507
p_{tunc}	0.616	0.616	0.616	0.653	0.664	0.685	0.682
p_{hic}	0.660	0.688	0.824	0.740	0.626	0.672	0.635
$CUB_{sed\text{-}autem}$	1.000	0.655	1.000	0.040	1.000	1.000	0.089
$CUB_{ergo\text{-}igitur}$	0.015	0.006	0.006	0.027	0.063	0.110	0.110
iPr, %	0.500	0.090	0.220	0.030	1.130	2.180	0.210

11.3. Conclusion: interstylar distance

According to the qualitative investigation, the texts **GV, CC** and **MB** are stylistically the least similar to **C.** They appear very different since they use a humanistic and Renaissance Latin rather than scholastic Latin. The closest match seems to be the **JG**. Book **PR** is also noteworthy since it contains many instances of the characteristic "*quidem*". The quantitative research surprisingly favours a very short text[222] **MW** and is not particularly negative to **MB** but in general confirms the findings of the qualitative investigation giving a high similarity score to **JG** and **PR,** very low to **GV** and **CC** and an average to **AB**.

The following conclusions seem to be justified:

- A high score of **MW** seems to indicate that Copernicus's **C** is similar to the Latin of *Abstemius* (Mikołaj Wodka of Kwidzyn). However, it would be wrong to conclude that it confirms L.A. Birkenmajer's hypothesis of Copernicus spending his pre-university *studium particulare* in Włoclawek under the guidance of a renowned astronomer *Abstemius*[223] or that he studied *Abstemius's* writings – for this purpose an additional analysis of the style similarities is needed, which we did not make[224].

[222] This text contains just a few letters of *Abstemius* – a clearly different literary genre might account for it failing to impress during the qualitative investigation and its short size for the results of the quantitative investigation.

[223] See L.A. Birkenmajer 1926.

[224] Contrary to L.A. Birkenmajer's opinion (1926, pp. 125–138), many other historians defended the view that Copernicus attended the school in Kulm / Chełmno

- A relatively high score of **JG** indicates that Copernicus's **C** is similar to the Latin of John of Głogów. However, it cannot be seen as a corroboration of the hypothesis of the influence of John of Głogów (and, perhaps, other Kraków professors) on Copernicus. For this purpose, an additional analysis of the style similarities is needed, which we did not make.
- A relatively high score of **PR** indicates that Copernicus's **C** is also similar to the Latin of *Epitome* (Peuerbach & Regiomontanus). It also cannot be seen as a corroboration of the hypothesis of the influence of this work on Copernicus. However, we know it from elsewhere: from the semantic analysis of the content of these works.[225]

12. Grand conclusion: (r)evolving[226] Copernicus

Habent sua fata libelli. The fate of a small book called *Commentariolus* has indeed been particularly special. The paper had been lost for centuries until it was found in Vienna and published by Maximilian Curtze.[227] Two other copies were then eventually found in the libraries of Stockholm and Aberdeen.[228] All of them are descendants of the only manuscript presented by Thaddaeus Hagecius (Tadeáš Hájek) in 1575[229] to Tycho Brahe. Hagecius in turn must have got it from Rheticus[230]. The early acquaintance of Rheticus with **C** could have been the stimulus for

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and not in Włocławek (with Abstemius) – see Hipler 1869, p. 486; Schmauch 1943, pp. 108–113; Wasiutyński 1938, p. 23 & p. 564, fn. 5; Barycz 1953, p. 19; Flis 1968; Nowak 1973; Mikulski 2015, pp. 331–333. On the other hand, Jeremi Wasiutyński (2003, pp. 172–175) argued that Copernicus studied in Włocławek, and the initiators of sending Nicolaus Copernicus to study in Włocławek in 1488 were Kallimach and Abstemius. Concluding this debate Janusz Małek (2013, s. 750) stated: Włocławek in Kujawy and Chełmno in Royal Prussia are equally probable places of Copernicus's middle school education "until convincing arguments are found to solve this puzzle".

[225] See L.A. Birkenmajer 1900, pp. 3–25.

[226] In Michał Kokowski's terminology – see Kokowski 2012b.

[227] Curtze 1878. See the full story in Appendix 1.1.

[228] Dobrzycki 1973b.

[229] L.A. Birkenmajer 1900, pp. 83–84, 634.

[230] Probably as inheritance. An alternative provenance is argued for in Dobrzycki, Szczucki 1989.

his eventful decision to undertake a long and costly voyage to the "*remotissimum angulum terrae*" which rescued **R** from the obscurity.

And now it seems the same **C** allows us to draw some important conclusions:

- In Kraków, Copernicus was presumably exposed to humanistic influences[231] and became a friend of Laurentius Corvinus[232], a member of the *Sodalitas Litterarum Vistulana*[233] – a humanistic academic society established by the honored poet Conrad Celtes. Then he spent nearly a decade studying at two Italian universities (Bologna and Padua) under equally likely strong humanistic influence.[234]

  However, it might be considered that many humanists started either trained as lawyers (in an 'old-fashioned way') or as theologians in the medieval, scholastic tradition[235]. In the beginning of the 16th century in northern Europe the humanism was still developing, so many humanists still had medieval traces in their writings.[236] Copernicus himself had a degree in canon law and might have even had some notarial practice while he was in Rome in 1500.[237]

  The endeavor to translate Theophylactus Simocatta's letters from Greek should be seen not only as the key to reading the ancient astronomical writings in original but as a typically scholastic attempt of self-education in an important ancient language as well. Besides, most probably Copernicus also improved his rhetorical skills in Latin at the same very time. These skills greatly helped him to increase the persuasive force of **R** lacking arguments of demonstrative certainty.
- Copernicus could get the first glimpses of his theory early, perhaps, even during his student years in Kraków, and John of Głogów could play a certain role in this.[238] Our findings, based

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[231] Segel 1989.
[232] Wasiutyński 1938, p. 41.
[233] Starnawski 1987.
[234] Kowalski 1924.
[235] Knight, Tilg 2015.
[236] *Ibid.*
[237] Gansiniec 1957; Biskup 1973, p. 45, nr. 44.
[238] John of Głogów is known as one of the proponents of *via moderna* in the Kraków university. Among other things he was famous for his knowledge of logic, he

only on one John of Głogów's work from 1513, show so far that the Latin of Copernicus's **C** is similar to the Latin of John of Głogów from 1513. However, *such a limited basis* is insufficient to state *at this stage of the project* that a possible early influence of *via moderna* on Copernicus thought has also been corroborated by our findings.

- It is very possible that it was **C** that resulted in the invitation of Paul of Middelburg to participate in the church calendar reform – according to Copernicus himself an important impetus to develop his theory.[239]

Nothing in copernicology (perhaps in the whole history of science) makes sense except in the light of evolution of mental models.[240] We have tried to shed such light on our subject moving in a direction from linguistics depths to conceptual heights. Allow us to state again what we managed to uncover. The qualitative and quantitative analysis of the Latin language level, involving a comparison of Copernicus's **C** on the one hand, and **M**, **L** and **R** on the other, has located a number of substantial differences that were not so easy to account for. In any case, the drastic evolution of Copernicus's writing style as discovered by us did require a substantial explanation. Following the footnotes made by us, it seems that we have managed to draw plausible conclusions about both the *Sitz im Leben* and the dating of *Commentariolus*. We discovered Copernicus (r)evolving from a scholastic Latin writer into a mature author armed with powerful rhetorical skills. This appears to be quite an appropriate portrait of a person who, working alone under the heavy burden of administrative, ecclesiastic, medicinal and even military duties, was nevertheless able to lay the first cornerstones in the magnificent structure of modern science.

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lectured to Peter of Spain. The thesis of influence of the Aristotelian tradition as well as of Jean Buridan and his followers on Copernicus thought has been defended by Konstanty Michalski (1916; 1927); Mieczysław Markowski (1971); Michał Kokowski (1996; 2001; 2004; 2009a; 2012b) and André Goddu (2010).

[239] See the Dedication Letter to the Pope Paul III from the Copernicus's preface to *De revolutionibus*; Marzi 1896; L.A. Birkenmajer (1924, pp. 225–231; 378–382); Struik 1925; Biliński 1973, pp. 40–47, 53–59.

[240] It is of course an allusion to the famous *dictum* of Theodosius Dobzhansky "Nothing in Biology Makes Sense except in the Light of Evolution". See Dobzhansky 1973.

13. Future research suggestions

Our original hope was to establish a progressive research program for future historians in which the adopted new research hermeneutics – the new interpretative tools for understanding or decoding analyzed texts – lead to the discovery of hitherto unknown facts.[241] And it does seem that the linguistic turn suggested by Ludwik Antoni and Aleksander Birkenmajer[242] in combination with the integrated multi-disciplinary approach suggested by Michał Kokowski[243] and the stylometry approach is a fruitful way forward. The following research horizons can easily be discerned:

- verification of our results using much more data – i.e. extending **A** corpus;
- making use of the Latin **NLP**;[244]
- locating some other peculiar Copernicus style markers;
- dating of **R** based upon stylochronometry and combining these studies with the paleographic research;[245]
- finding other external influences on Copernicus writing style and combining the stylometric studies with the terminological research;[246]
- building a substantial database of relevant Latin texts, including Copernicus's own library, in combination with an adequate **NLP** should allow to run cross-reference similarity checks and in this way discover new hidden influences on Copernicus.

We sincerely invite all Copernican scholars to critically discuss the proposed approach, its advantages and disadvantages, and the obtained results.

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[241] See Lakatos 1970a; 1970b; 1971; 1974; 1978; Musgrave, Pigden 2021.

[242] See L.A. Birkenmajer 1900; 1924; A. Birkenmajer 1968.

[243] See Kokowski 1996; 2001; 2004; 2009a.

[244] Building a software interface with the existing morphological analyzers, e.g. as described in (Passarotti, et al. 2017), is a natural choice.

[245] As described in *e.g.* Rosińska 2001.

[246] In particular, it seems promising to trace the terminology development within the Polish astronomical tradition. The books of Waniakowa 2003 and Maciąg-Fiedler 2016 can be seen as the first important steps in this direction.

14. Acknowledgments

With the modern speed of life, the years in the famous Horatian recipe for bearing intellectual fruit should probably be upgraded to months.[247] Being allowed to do that we, just like Copernicus, could boast that our paper lay hidden *iam in quartum nouennium*. Indeed, several years have passed since a short correspondence with Professor Emeritus of astronomy and of the history of science at Harvard University Owen Gingerich initiated this project. This research in its early stage also benefited from the communication with the prominent Dutch historian of science Floris Cohen, who, having discussed our approach with Professor Emeritus of UCSD Robert Westman, expressed a vivid interest in it.

Once the qualitative analysis of the texts had been launched the generous assistance of the Dutch neo-Latin expert Dr. Verena Demoed could not be underestimated. We have already mentioned the fruitful discussions with Professor Dr. Jan Bloemendal, a senior researcher in the Huygens Institute for the History of the Netherlands at the Royal Netherlands Academy of Arts and Sciences. The mathematical model of "synonymetry" was borne out of the discussion with him.

It is not easy to dive into the deep seas of the booming science of stylometry without professional guidance. We were extremely lucky to be helped in that by a team of brilliant advisors:

- Dr. James W. Pennebaker, Professor of Psychology, University of Texas at Austin;
- Dr. Ryan Boyd, Lecturer in Psychology, University of Lancaster;
- Dr. Jacques Savoy, Professor of Computational Linguistics, Université de Neuchâtel.

Appendix 1. Historical frames of *Commentariolus*

1. Provenance of *Commentariolus* manuscripts

The existence of *Commentariolus* was first reported by Tycho Brahe (14 December 1546 – 24 October 1601) in his book *Astronomiae instau-*

[247] Horace '*Ars Poetica*' 389: *Siquid tamen olim / scripseris, in Maeci descendat iudicis auris / et patris et nostras, nonumque prematur in annum/ membranis intus positis; delere licebit / quod non ediderіs; nescit uox missa reuerti.*

ratae Progymnasmata …. de nova stella anno 1572 … (published posthumously in 1602, pp. 479–480). Brahe called this work *Tractatulo quodam de Hyphotesibus a se constitutis* and mentioned that he had received a copy of this work in Regensburg from Thaddaeus Hagecius (Tadeáš Hájek, 1 December 1525 – 1 September 1600).[248]

Then the paper was lost for centuries until Maximilian Curtze found a 16th century copy in 1877 (in the Vienna Imperial Court Library, now the Österreichische Nationalbibliothek) belonging in 1600 to Tycho's assistant Christen Sørensen (Longomontanus); unfortunately, it lacked a major part of the lunar theory. This so-called "V-copy" was entitled *Nicolai Copernici de hypothesibus motuum coelestium a se constitutis commentariolus.*

Two other complete copies have eventually been found: the Stockholm copy, which used to belong to Johannes Hevelius (1611––1687), found by Arvid Lindhagen in 1881 in the Royal Academy of Sciences in Stockholm (the so-called "S-copy"); and the Aberdeen copy, which used to belong to Duncan Liddel (1561–1613) and copied in Rostock on 2 November 1585 (from Tycho Brahe's copy), found by William P. D. Wightman and Jerzy Dobrzycki in 1962–1965 in King's College Library in Aberdeen (the so-called "A-copy").[249]

All of them are (probably) descendants of the same manuscript presented by Tadeáš Hájek to Tycho Brahe in Regensburg in 1575.[250]

Hagecius in turn got it either a) directly from Rheticus in 1573[251] or b) indirectly, via Paul Wittich (c. 1546–1586), who received a copy

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[248] See Prowe 1883–1884, vol. I, part 2, p. 285 & fn.*; L.A. Birkenmajer 1900, pp. 634–637; A. Birkenmajer 1933; Brachvogel 1935, pp. 41–42; Wasiutyński 1938, p. 581 fn. 95: "It is debatable whether the title comes from Copernicus or from a later copyist. The first thesis was put forward by prof. Alexander Birkenmajer (1933). The second thesis is defended by, among others Eugeen Brachvogel (1935, pp. 41–42)"; Dobrzycki, Szczucki 1989; p. 25.

[249] See Curtze 1878, pp. 1–17; Lindhagen 1881; Wightman 1962, p. 67; Dobrzycki, Wightman 1965; Dobrzycki 1973; Dobrzycki, Szczucki 1989; Rosen 1937, p. 123; 1971, p. 6; 1985, pp. 75–80; Swerdlow 1973.

[250] See L.A. Birkenmajer 1900, pp. 83–84, 634; Rosen 1985, p. 80; Swerdlow 1973, p. 423; Dobrzycki, Szcczucki 1989, p. 25. Only Swerdlow calls this thesis "probable": "All three are probably descended from Tycho's copy, are far removed from the original, and preserve a faulty, possibly an exceedingly faulty, text".

[251] Primarily, L.A. Birkenmajer insisted that Rheticus hadn't received *Commentariolus* (and the *Letter against Werner*) from Copernicus and it is not via him that it came to Hagecius (L.A. Birkenmajer 1900, p. 637). Then he changed his narrative: Rheticus got

of a text, called *Epitome Copernici* (i.e. presumably *Commentariolus*) from his uncle Balthasar Sartorius Vratislaviensis, who in turn used to visit Rheticus in Kraków[252].

Moreover, another copy of *Commentariolus*, described as *sexternus Theorice asserentis Terram moveri, Solem vero quiescere* (a six-folio theory asserting that the earth moves while the Sun remains at rest[253]) which could be a valuable autograph, owned by Maciej of Miechów before 1 May 1514, has apparently been lost[254].

2. Title of *Commentariolus*

So far, four titles are known:

- *Sexternus Theorice asserentis Terram moveri, Solem vero quiescere*, before 1 May 1514 (as listed in the library catalog of Maciej of Miechów)[255].
- *Epitome Copernici*, probably before 4 December 1574 (the date of Rheticus's death; the copy was received by Balthasar Sartorius Vratislaviensis probably from Rheticus himself, then transferred to Paul Wittich; the information is based on Andreas Dudith's letters from the 1st of January and 12th of February 1589 to Johannes Praetorius)[256].
- *Tractatulo quodam de Hyphotesibus a se constitutis*, 1575 (as mentioned by Tycho Brahe)[257].

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a copy of *Commentariolus* and *Letter against Werner* during his stay in Kraków *c.* 1555––1575, and passed them in 1575 to Hagecius (L.A. Birkenmajer 1924, pp. 213–219).

[252] The correspondence of Andreas Dudith (1533–1589) is the source of this information – see Dobrzycki, Szczucki 1989, pp. 25–26. It is worth adding here that L.A. Birkenmajer 1900, p. 610, nr. 25, pp. 614–615, nr. 29–30 already drew attention to Andreas Dudith's correspondence and his relationship with Rheticus.

[253] The English translation belongs to R. Westman 2011, p. 103.

[254] According to L.A. Birkenmajer (1924, pp. 223–224) at that time it was still located somewhere in Russian Petrograd (Petersburg) together with the other papers stolen from the library of the Order of Holy Sepulcher (in Polish Bożogrobcy) in Warsaw during the partition of Poland. Leszek Hajdukiewicz (1962) was unable to find this manuscript in the Polish libraries. Our own inquiries to the Petersburg libraries resulted in the official reply that all such books were returned to Poland back in 1930s.

[255] See L.A. Birkenmajer 1924, pp. 200–202, 208; Hajdukiewicz 1960, p. 384.

[256] See Dobrzycki, Szczucki 1989, pp. 26–28. About Paul Wittich's astronomical network – see Gingerich, Westman 1988.

[257] See Prowe 1883–1884, vol. I, part 2, p. 285 & fn.*; L.Birkenmajer 1900, p. 84.

- *Nicolai Copernici de hypothesibus motuum coelestium a se constitutis commentariolus*, before 1687 ("S-copy", belonging to Johannes Hevelius, who died in 1687).

On the basis of the information known so far, one can only speculate whether these titles were original or not.

3. Dating of *Commentariolus*

The early conjectures were that *Commentariolus* was written in 1533 or even in 1539[258]. Such a dating was first challenged by Ludwik Antoni Birkenmajer in 1900, based on the content comparison of *Commentariolus* and *De revolutionibus*,[259] who then developed it further in his works of 1920 and 1924. Let us follow the history of his findings and their reception.

In 1840, a bibliographer Adam Benedykt Jocher (1840, pp. 112––113) drew attention to the fact that the translator of *Theophilacti scolastici Simocati epistolae morales, rurales et amatoriae* (Kraków, 1509) was not Laurentius Corvinus (Raabe) as was thought at the time, but Nicolaus Copernicus. In 1873 Franz Hipler (1873, pp. 72–102) republished this work with his comments. It included on pp. 74–77, as an introduction, a poem of Laurentius Corvinus that is now called *Farewell to Prussia*. In 1873, two authors drew attention to the fact that in Corvinus's preface (in verses 21 and 25–30) there is a clear allusion to Copernicus and his astronomical pursuits: Ignacy Polkowski (ed. 1873–1875, vol. 1, pp. 3–4; 1873, p. 165) and Franciszek Karliński (1873, pp. 16–17).

The most relevant are the following verses (27–30) of this poem: "*Qui celerem lune cursum alternosque meatus / Fratris: cum profugis tractat et astra glebis [sic!] / Mirandum omnipotentis opus: rerumque latentes / Causas scit miris quaerere principijs*". In Edward Rosen's (Copernicus 1985, p. 27) translation: "He discusses the swift course of the moon and the alternating movements of its brother as well as the stars together with the wandering planets – the Almighty's marvelous creation – and he knows how to seek out the hidden causes of phenomena by the aid of wonderful principles".

Based on a wrong translation and an overinterpretation, Karliński (1873, p. 17) came to an unequivocal conclusion: it follows directly from

[258] See Curtze 1878, pp. 2–4, 9, 70; Prowe 1883–1884, vol. II, p. 286; Dreyer 1890, p. 83, chap. 4, fn. 16/1894, p. 87, and Appendix.

[259] See L.A. Birkenmajer 1900, pp. 70–88.

this poem (i.e. from the "wonderful principles"/"*miris … principijs*") that Copernicus analyzed the issue of the movements of the Earth already at the court of Bishop Watzenrode in Heilsberg (Lidzbark). Karliński's judgement was accepted by his son-in-law – Ludwik Antoni Birkenmajer (1900, pp. 80, 168). After some further source research, L.A. Birkenmajer (1900, pp. 70–88) established the following possible dates:

a) *terminus post quem* – *Commentariolus* was created after 1496 or rather 1504 or 1508, as it used *Epitome in Almagestum* published in 1496, which belonged to Copernicus before 1508 or even before May 1504 (1900, p. 5);
b) *terminus ante quem* – *Commentariolus* was written before 1515: 1) as it does not use the Venetian edition of the *Almagest*, which appeared on January 10, 1515 (L.A. Birkenmajer 1900, pp. 6–13); 2) thanks to his observations of 1515 Copernicus discovered the variability of planetary apsides (this issue is not mentioned in *Commentariolus*), therefore *Commentariolus* was created before that date (L.A. Birkenmajer 1900, pp. 72–73);
c) the probable dates of the composition of *Commentariolus*: Copernicus was working on the *Commentariolus* somewhere between 1504 and January 1 or June 5, 1512[260] (because the lengthy research process should also be taken into account);
d) the admissible date of the *Commentariolus* writing might be even 1500 or 1501 (Copernicus's presence in Rome mentioned by Rheticus in *Narratio prima*,[261] or the time when Copernicus did not know Greek well enough, *i.e.* before 1503. See L.A. Birkenmajer 1900, p. 82; pp. 99–127).

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[260] The 1st of January 1512 is the date of observation of Mars' conjunction; the 5th of June 1512 is the date of observation of Mars' opposition, and the 5th of May 1514 – of Saturn's opposition (L.A. Birkenmajer 1900, pp. 77–78; 164). Thanks to these observations, Copernicus discovered the variability of planetary apsides. However, this issue is not considered in *Commentariolus*. Therefore, according to L.A. Birkenmajer, *Commentariolus* was created before 5th of June 1512 (L.A. Birkenmajer 1900, pp. 72–73). *NB:* Copernicus could have noticed the changeability of the apsides, while choosing not to analyze it in *Commentariolus* and preferring to deal with it in his mature work *De revolutionibus*.

[261] Rheticus 1540, p. A_{2v}; Gassendi 1655, p. 291; Tiraboschi 1823, p. 589; Krzyżanowski 1843, p. 6; Hipler 1873, p. 212; Prowe 1883, vol.1, part 1, p. 284, fn.*; L.A. Birkenmajer 1900, p. 105; Biskup 1973, p. 42, nr. 36.

After further archival research L.A. Birkenmajer (1920, pp. 18–20; 1924, pp. 199–244) finally suggested the following cut-off dates:

a) *terminus post quem* – 1501, since *Commentariolus* depends on Georgio Valla "*De expetendis et fugiendis rebus*" (1501) (L.A. Birkenmajer 1924, p. 165);
b) *terminus ante quem* – 1st of May 1514 comes from the date of the entry entitled *sexternus Theorice asserentis Terram moveri, Solem vero quiescere* (*A Six-Folio Theoric Asserting That the Earth Moves While the Sun Remains at Rest*) in the library of Maciej of Miechów;
c) *terminus ante quem* – before 1509, due to the "undoubted allusion" of Laurentius Corvinus in the poetic introduction to the letters of *Theophilacti scolastici Simocati* translated by Copernicus (1920, p. 19).

These L.A. Birkenmajer's findings were considered and sometimes revised by other prominent researchers on the topic[262]:

a) his son Aleksander Birkenmajer (1933) set the time of writing *Commentariolus* to 1502–1514;
b) Jeremi Wasiutyński (1938, p. 581, fn. 95) cited A. Birkenmajer (1933);
c) Ernst Zinner (1943/1988, p. 186) cited L.A. Birkenmajer (1924, pp. 199–224);
d) Jerzy Dobrzycki (1973); Jerzy Dobrzycki, Lech Szczucki (1989) cited L.A. Birkenmajer (1924); Dobrzycki (2001) accepted Karliński's and L.A. Birkenmajer's conjecture;
e) Noel Swerdlow (1973, p. 431) cited among others L.A. Birkenmajer (1900) and A. Birkenmajer (1933) and concluded that "there is insufficient evidence to determine how long before 1514 Copernicus developed his new planetary theory";
f) Edward Rosen (1939, 2nd ed. 1957; 3rd ed. 1971, p. 7) cited A. Birkenmajer (1933), but said that "the date of composition of *Commentariolus* cannot be precisely determined";
g) Edward Rosen (in: Copernicus 1985, pp. 79–80) finally stated that *Commentariolus* was written between the second half of 1508 and the 1st of May 1514 (based on Hajdukiewicz (1960, p. 218, nr. 189) resolving the Corvinus contradictory evidence in favor of *terminus post quem*;

[262] See Kokowski 2006, p. 277 & fn.2, pp. 295–296.

h) Jeremi Wasiutyński (2003, pp. 330–340), cited L.A. Birkenmajer (1900; 1924); A. Birkenmajer (1933); *terminus post quem* – 15th July, 1502 since *Commentariolus* depends on *Almanach perpetuum* by the Jewish astronomer Abraham Zacut of Salamanca, edited by Alphonsus de Cordoba called Hispalensis (*Commentariolus* refers to the value of the tropical year assumed in this Almanach);
i) Owen Gingerich (2004, p. 43 / 2006, p. 41) referred to Jerzy Dobrzycki's findings;
j) André Goddu (2010, p. 244, fn. 110–111) accepted as the *tempus ante quem* 1512 (based on the observations) and 1514 (based on the entry in the library of Maciej of Miechów) referring to L.A. Birkenmajer (1900); Rosen (1985); Dobrzycki, Szczucki (1989); Schmeidler 1993; Swerdlow 1973; Biskup 1973 and suggested as *tempus post quem* 1510.
k) Robert S. Westman (2011, p. 100, en. 144–146 on. p. 531) referred to Swerdlow (1973), Rosen (1985) and Dobrzycki (1973; 2001); on (pp. 102–103, en. 161 on p. 532) mentioned Maciej of Miechów entry of 1 May 1514 referring to Zinner (1943 / 1988, p. 186); L.A. Birkenmajer (1924, pp. 199–224); Rosen (Copernicus 1985, p. 75).
l) Pietro Daniel Omodeo (2014, p. 11) referred to Biskup 1973 (p. 50, nr. 55; pp. 63–64, nr. 91); L.A. Birkenmajer (1900, pp. 70––88); Swerdlow (1973, p. 431).

On the other hand, these L.A. Birkenmajer's findings did not reach philosophers of science, such as Karl R. Popper, Thomas S. Kuhn, Norwood R. Hanson, Imre Lakatos, Alan Musgrave, Elie Zahar, Michael Heildelberger, Larry Laudan, Martin V. Curd, Clarc Glymour, and Ernan McMullin[263].

4. Recipients of *Commentariolus*

According to L.A. Birkenmajer, Copernicus disseminated the *Commentariolus* before May 1st, 1514:

a) in a narrow circle of friends which included Laurentius Corvinus (Wawrzyniec Raabe), Johannes Dantiscus, Tiedemann Giese and Bernard Wapowski;

[263] See the works of these authors listed in the bibliography.

b) among Kraków professors: Maciej of Miechów, Stanisław Seliga, Marcin Biem, Mikołaj of Szadek and Mikołaj of Wieliczka; *Commentar*iolus came to Maciej of Miechów, most probably via Wapowski.

Moreover, according to L.A. Birkenmajer, Rheticus didn't know about the existence of *Commentariolus* before his stay in Kraków from around 1555 to 1573. Via Rheticus, during his stay in Kraków or shortly after it (Rheticus died on 4 December 1574 in Košice), the copies of *Commentariolus* and *Letter against Werner* came into possession of his friend Tadeáš Hájek, who finally handed them over to Tycho Brahe in 1575.[264]

Jerzy Dobrzycki and Lech Szczucki (1989) advocated another way of *Commentariolus's* provenance. The letters of Andreas Dudith (1533––1589)[265] from the 1st of January and 12th of February 1589 addressed to a Wittenberg astronomer Johannes Praetorius, who lived in Kraków from 1569 to 1571 in Dudith's house, mention that a document called *Epitome Copernici* (*i.e.* presumably *Commentariolus*) was owned by a physician and mathematician Balthasar Sartorius Vratislaviensis. He in turn has likely received this copy from Rheticus (who died on the 4th of December 1574). Then the manuscript was passed to Sartorius's relative, astronomer Paul Wittich (c. 1546–1586) who was living in Wrocław and was acquainted with, among others, Thadeus Hájek.[266]

However, there is no evidence on how and when Rheticus got *Commentariolus – Narratio prima* and other historical documents are silent on the subject.

Appendix 2. Reception of Copernicus's ideas before 1543

Though Copernicus did not publish any astronomical work before 1542–1543, his views on these matters were discussed in Europe from at least 1516.

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[264] See L.A. Birkenmajer 1924, pp. 214–219.

[265] Dudith stayed in Kraków from 1567 to the fall of 1577, where in the late 1560s he met Rheticus; he stayed in Wrocław from the fall of 1577 until his death in 1589.

[266] See Dobrzycki, Szczucki 1989, pp. 25–26.

On June 4th, 1516, Paul of Middelburg informed Pope Leo X that the Lateran Council had received many suggestions about the proposed calendar reform, including the work of Copernicus. This information was then included in Paul Middelburg's *Secundum compendium*, disseminated in the Pope's breve on July 8, 1516, and reached universities, learned theologians, and astronomers[267].

Celio Calcagnini (1479–1541), who probably learned about Copernicus's ideas during his stay in Kraków in 1518,[268] rhetorically defended the moving Earth hypothesis in his *Quomodo coelum stet, terra moveatur, vel de perenni motu terrae Commentatio* published posthumously in 1544.[269]

Caspar Peucer (1525–1602), in the preface to the *Elementa doctrine de circulis coelestibus* (Wittenberg 1551) noted that "Nic. Copernicus circa a. Christi 1525 maxime inclaruit" (Nic. Copernicus became the most famous in ca. 1525).[270]

In 1531 Simon Hájek in Prague got a copy of the *Letter against Werner*; this copy later belonged to his son Tadeáš Hájek.

In the summer of 1533 in Rome, the learned orientalist Johann Albrecht Widmannstadt (1506 – 28 March 1557) outlined the Copernican

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[267] See L.A. Birkenmajer 1924, pp. 378–382; Biskup 1973, p. 67, nr. 103.

[268] This is the thesis of Franz Hipler (1879, pp. 575–586; 1882, pp. 51–82), who considered the correspondence between Celio Calcagnini and Jacob Ziegler from 1518 to 1524 concerning the Earth's motion. Ludwik Antoni Birkenmajer (1900) agreed with him. According to Hipler, Copernicus's ideas reached Calcagnini via Johannes Dantiscus and according to L.A. Birkenmajer, via Jan Benedykt Solfa, see Hipler 1882, pp. 51–82; L.A. Birkenmajer 1900, pp. 480–491. However, already Artur Wołyński (1873, pp. 57–59) suggested that Calcagnini must have learned the cosmological views of Copernicus via Jacob Ziegler.

[269] According to Pietro Daniel Omodeo: "It should be remarked that the name of Hiketas is here [Calcagnini's *Quomodo coelum stet, terra moveatur, vel de perenni motu terrae Commentatio*] misspelled as "Nicetas" in the same manner as in *De revolutionibus*. This could be evidence, albeit weak, for Copernicus's acquaintance with Calcagnini's writing" (Omodeo 2014, p. 213).

We disagree with this opinion: Copernicus did not know Calcagnini writings, which were published only in 1544, and the coincidence with "Nicetas" instead of "Hicetas" is caused by reading the same work: Cicero, *De natura deorum, Academica*. Copernicus cited Cicero (with "Nicetas Syracosius") not only in *De revolutionibus* (1543) but also in a note given in his own copy of Plinius Secundus, *Historiae Naturalis* (1487), Liber Secundus, fol. aii verso. See Curtze 1878a (ed.), p. 40; Lynn 1893; L.A. Birkenmajer 1900, p. 567; 1924, p. 173; Rosen 1978, p. 341; 1992, p. 341; Goldstein 2002, pp. 232–233.

[270] See Hipler 1873, pp. 266, 279; L.A. Birkenmajer 1900, p. 80.

view about the Earth motion *(Copernicianam de motu terrae sententiam*) to Pope Clement VII and Cardinals Francis Orsini and John Salviati[271].

In the second half of 1533, Nicolaus Copernicus from Wrocław (*Vratislaviensem Copernicum*), Petrus Apianus from Ingolstad (*Ingolstadiensem Apianum*), Heronimus Scala [probably Julius Cesar Scalinger], Hieronimus Cardanus from Milan (*Cardanum Mediolanensem*) and Gemma Frisius (*Gemmam Frysium*) took part in a polemic about the comet that appeared in June 1533[272].

On October 15, 1535, Bernard Wapowski (1450 – 25 November 1535), canon of Kraków, a friend of Copernicus, sent from Kraków a copy of the astronomical almanac to the Viennese diplomat Siegmund von Herberstein (1486–1566), calculated using Copernicus's theory with a request to publish and disseminate it among the German mathematicians (however, the almanac has never been published and is considered lost).[273]

Around 1535, Copernicus's hypotheses were ridiculed in the play *Morosophus* (A stupid sage) by Wilhelm Gnapheus, a gymnasium teacher

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[271] See Tiraboschi 1823, vol. VII, p. 648; Hipler 1872, p. 120; Polkowski 1873, pp. 268–269; Wołyński 1873, pp. 59–60; Prowe 1883, vol. 1, part 2, p. 274, fn.*; L.A. Birkenmajer 1900, pp. 537–538; Biskup 1973, p.153, nr. 339.

[272] This information comes from Zenocarus Gulielmus à Scauwenburgo's work entitled *De Republica, vita, moribus, gestis, fama […] Imperatoris, Caesaris Augustii Quinti Caroli […] libri septem* (*Gandavi* 1559, pp. 197–198) and the 2nd ed. entitled *De vita Caroli Quinti Imperatoris* (Antverpiae 1559, pp. 197–198) – see Curtze 1878a (ed.), pp. 41–43; L.A. Birkenmajer 1900, pp. 525–532; Sikorski 1966, nr. 348; 153 1973, nr. 335. It is reasonable to assume that Copernicus wrote at least a letter about this issue. However, no document of this kind has survived. Due to the fact that there are no other sources confirming this debate, Marian Biskup doubts that Copernicus took part in this debate.

On the other hand, in 1876, when Lauigi Napoleone Cittadella discovered the original notarial deed proving the doctoral promotion of Copernicus in Ferrara on May 31, 1503, we learned that Copernicus was not only a Warmian canon, but also a scholastic at the Holy Cross Church at Wroclaw. From other historical sources we know that he was linked with *Wratislavia* by family ties, and had in this city the *scholasteria* from at least 1503 to 1538. This information substantiates the thesis of Zenocarus Gulielmus à Scauwenburgo that "*Vratislaviensem Copernicum*" participated in the debate about the comet of 1533, see L.A. Birkenmajer 1924, pp. 1–49; Biskup 1973, p. 44, nr. 42; p. 43, nrs. 43–44; p. 168, nr. 387; p. 171, nr. 395.

[273] Brachvogel 1933, pp. 238–239; Zinner 1937, p. 57; Wasiutyński 1938, pp. 394––395; Biskup 1973, pp. 155–156, nr. 345.

from Elbing/Elbląg. We owe this information to some letters of Tiedemann Giese which were known to Jan Brożek[274] but a historian of science Jeremi Wasiutyński in 1938 and a literary scholar Józef Lassota in 1963 showed that it was only a historiographic myth: the comedy says next to nothing about the cosmology but rather makes fun of the alleged human vices of Copernicus.[275]

Before 1536, Tiedemann Giese, then a canon of Warmia, wrote the treatise *Hiperaspisticon* defending the teachings of Nicolaus Copernicus about the Earth motions (it is not extant).[276]

On the 1st November of 1536 Nicolaus von Schönberg, Cardinal of Capua, sent a letter from Rome to Copernicus in which: a) he mentioned that already *several years ago* he had heard of Copernicus being praised, and b) recognizing the greatness of Copernicus's ideas he asked for a detailed exposition of them[277].

At the same time the news of Copernicus's astronomical and cosmological ideas must have reached Germany. It was during his trip to some outstanding scholars in Nürnberg / Nuremberg (where Johannes Schöner resided), Ingolstadt, Tübingen and Feldkirch that Georg Joachim Rheticus, professor of Wittenberg University, decided to undertake a long and costly voyage to Copernicus in Warmia[278].

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[274] See Starowolski 1627, p. 158; Gassendi 1654, p. 40, an appendix at the end of the book, concerning the biography of Tycho Brahe, and before the biographies of Peuerbach and Regiomontanus; Hipler 1868, p. 538, preprint pp. 63–64; Polkowski 1873, p. 202; L.A. Birkenmajer 1924, pp. 232–240; Biskup 1973, p. 182, nr. 432; p. 189, nr. 445; Kokowski 2009a, p. 100, fn. 327–328, p. 367.

[275] See Wasiutyński 1938, pp. 444–453; Lewański 1959; Kokowski 2009a, p. 100, fn. 329, pp. 367–368.

[276] Jan Brożek had it. See Hipler 1873, p. 286; L.A. Birkenmajer 1900, p. 657; Biskup 1973, p. 157, nr. 348.

[277] Hipler 1873, pp. 114–115; Wołyński 1873, pp. 53–54; Polkowski (ed.) 1873, vol. 1, pp. 89–90; Polkowski 1873, pp. 268–269; Prowe 1883, vol.1, part 2, p. 276, fn. * and pp. 276–278; L.A. Birkenmajer 1900, pp. 533–537; Wasiutyński 1938, pp. 399–400; Biskup 1973, p. 160, nr. 359.

[278] See Rheticus 1540; Hipler 1873, pp. 222–225; Prowe 1883–1884, vol. I, pt. 2, pp. 519-520, fn. ***, vol. II, pp. 382–386; Burmeister 1967–1968, vol. III, pp. 49–54; Biskup 1973, p. 188, nr. 442; pp. 206–207, nr. 487; Kraai 2001, pp. 75–86; Barker, Goldstein 2003; Danielson 2004. Note: There is no source evidence that Rheticus knew *Commentariolus* as early as in 1538 (thanks to talks with Johannes Schöner or in some other way) and that it stimulated him to undertake the journey to Warmia.

He came there after the 14th of May 1539 and left in September 1541[279] only. Already on the 23rd of September 1539 his *Narratio Prima* was completed. This work was written in a form of a letter to Johannes Schöner in Nürnberg / Nuremberg and described Copernicus's theory; its first edition was issued after 14 February 1540 in Danzig, the second in 1541 in Basel.[280] And it was Rheticus who rescued *De revolutionibus* from obscurity and helped to publish it in Nuremberg, Germany in 1543.

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[279] See Hipler 1873, p. 288; L.A. Birkenmajer 1900; 1920, pp. 20–21; Biskup 1973, p. 181, nr. 420; pp. 181–182, nr. 442.

[280] Rheticus 1540; Hipler 1873, p. 222; Prowe 1883, vol. I, part II, pp. 387–476); Polkowski (ed.) 1873 vol. 1, pp. 98–114; Rosen 1939, 2nd ed. 1959, 3rd ed. 1971, pp. 106–196; Biskup 1973, p. 184, nr. 428; p. 185, nr. 434; pp. 197–198, nr. 467; Danielson 2004.

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