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FOCAL POINT

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Was Copernicus an Astrologer?

Abstract

The question 'Was Copernicus an astrologer' is *prima facie* very clear, while in fact being quite ambiguous. This question should rather be regarded as a vast topic covering lots of more concise questions such as 'Was Copernicus thoroughly educated in astrology?', 'Did Copernicus believe in astrology?' or 'Did a mature Copernicus practice astrology?'

Unfortunately, thus far, consensus has not been achieved among historians on any of them. Accordingly, the topic has been for some time, and still is, a battlefield of the most acrimonious debates in Copernicology, nay, perhaps in the whole history of science.

Carefully made distinctions and subsequent analysis of the common *pro et contra* arguments enabled this paper to arbitrate the different perspectives. None of the arguments has been found to have a decisive force. In general, while the *pro* lines of reasoning are normally based upon insecure or even faulty inductive logic, their *contra* counterparts often suffer from *ex silentio* inferences or even *ad ignorantiam* fallacy.

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Two new, subtle arguments have been introduced instead. They can be considered as genuine new evidence allowing for the resolution of some lingering doubts. First, the natal charts of Copernicus that were cast in the middle of the 16th century have been studied. The excessively exact birth hour of Copernicus at 4:48 PM has quite naturally been expected to be a result of a preliminary astrological rectification. However, apparently it was not rectified by the algorithms most popular at the time. The findings suggest the number-symbolic rather than astrological inclinations of Copernicus.

Further, a careful analysis of Copernicus's annotations in the *Alfonsine Tables* revealed a link between the misprints corrected by him and the ancient observations he included in *De Revolutionibus*. Consequently, an extensive astrological use of the tables by him can be excluded with a high probability. Moreover, Copernicus likely never used *Regiomontanus Tables* on a regular basis either.

The conclusion integrates all the available arguments pertinent to the relationship of Copernicus with astrology.

Keywords: *Copernicus, astrology, rectification, Alfonsine Tables, Prutenic Tables, Regiomontanus Tables*

Czy Kopernik był astrologiem?

Abstrakt

Pytanie „Czy Kopernik był astrologiem?" jest na pierwszy rzut oka bardzo jasne, choć w rzeczywistości jest dość dwuznaczne. Należy je raczej traktować jako obszerny temat obejmujący wiele bardziej szczegółowych pytań, takich jak: „Czy posiadał gruntowne wykształcenie w zakresie astrologii?", „Czy wierzył w astrologię?" lub „Czy dojrzały Kopernik zajmował się astrologią?".

Niestety wśród historyków jak dotąd nie udało się osiągnąć konsensusu co do żadnej odpowiedzi. W związku z tym temat ten był i nadal jest polem najzacieklejszych debat w kopernikologii, a nawet w całej historii nauki.

Starannie dokonane rozróżnienia i późniejsza analiza powszechnych argumentów za i przeciw umożliwiły w tym artykule rozstrzygnięcie różnych perspektyw. Żaden z argumentów nie okazał się decydujący. Ogólnie rzecz biorąc, chociaż rozumowania „za" zwykle opierają się na niepewnej lub nawet błędnej logice indukcyjnej, ich przeciwne odpowiedniki często cierpią z powodu wnioskowania *ex silentio* lub nawet błędu *ad ignorantiam*.

Zamiast tego wprowadzono dwa nowe, subtelne argumenty. Można je uznać za rzeczywiście nowy materiał dowodowy, pozwalający na rozwianie niektórych utrzymujących się wątpliwości. Najpierw zbadano horoskopy urodzeniowe Kopernika, sporządzone w połowie XVI wieku. Naturalnie spodziewano się, że zbyt dokładna godzina narodzin Kopernika, czyli 16:48, będzie wynikiem wstępnej korekty astrologicznej. Jednak najwyraźniej nie zostało to naprawione przez najpopularniejsze wówczas algorytmy. Odkrycia sugerują raczej liczbowe niż astrologiczne skłonności Kopernika.

Co więcej, wnikliwa analiza adnotacji Kopernika w *Tablicach Alfonsyńskich* ujawniła związek pomiędzy poprawionymi przez niego błędami drukarskimi a starożytnymi obserwacjami, które zamieścił w *De Revolutionibus*. W związku z tym z dużym prawdopodobieństwem można wykluczyć szerokie astrologiczne wykorzystanie przez niego tablic. Kopernik ponadto prawdopodobnie nigdy też nie korzystał regularnie z *Tablic Regiomontana*.

Konkluzja integruje wszystkie dostępne argumenty dotyczące związku Kopernika z astrologią.

Słowa kluczowe: *Kopernik, astrologia, rektyfikacja, Tablice Alfonsyńskie, Tablice Pruskie, Tablice Regiomontana*

1. Introduction[1]

Astrology has undoubtedly played an important role in the evolution of humans' ideas about themselves and the Universe. Lured by the presumed ability of the ancient art to predict or even influence the future, people sought unintentionally not merely astronomical, but also mathematical knowledge for hundreds and thousands of years. *A fortiori*, the mysterious stars, being virtually unimpeded by the forces of friction ubiquitous in the sublunar world of generation and corruption, moved in a regular way, constituting an ideal laboratory under the open sky allowing for naked eye observations (or observations aided by simple instruments). This led to the development of models of unprecedented precision which in turn paved the way for the development of science in general, all the way to Newton's celebrated synthesis in the 17th century.

Unexpectedly, science, having been born, proceeded to distance itself from what used to be the *conditio sine qua non* of its very existence, *viz.*, astrology. People dropped the ladder which had helped them climb to modern epistemological heights. The rating of the former divine art now belonged to the dustbin containing the pseudo-sciences and medieval superstitions. Therefore, it is no surprise that Copernicus's relationship to astrology has been perceived by many as having a palpable influence on his scientific status. Was he a revolutionary genius, far ahead of his time? Or was he a typical medieval scholar discovering geokinetic cosmology by pure luck? Different general portraits of Copernicus, which historians had in mind, in the absence of indisputable facts, subconsciously determined their choice of probabilistic reasonings. The clash of these visions inevitably produced emotionally charged discussions.[2] One of the goals of the present article is to provide a rational, objective analysis of the available evidence.[3]

2. Specifying the research questions

The question 'Was Copernicus an astrologer?', although seemingly short and clear, is in fact inherently ambiguous. Let us split it into several more concisely formulated questions (signified with a Q-number combination for future reference) to allow for an unequivocal interpretation. What makes a person an astrologer in the modern sense of the word? Is it:

- Education or training in the subject, which results in knowledge of the major concepts and models as well as skills in applying its rules and algorithms? Accordingly, we should ask 'Was Copernicus thoroughly educated in astrology? Did he possess an expert knowledge of astrology? Did he possess the skills to apply its rules and algorithms?' (**Q1**)

[1] The article is an extension of the theses of a paper presented during the conference 'Copernicus and Astrology' organized by Commission on the History of Science, Polish Academy of Arts and Sciences and Science Studies Research Unit, Institute for the History of Science, Polish Academy of Sciences (29.05.2024).

[2] The most recent of those discussions occurred after Professor Robert Westman published his *magnum opus* 'The Copernican Question' (Westman 2011). Some of its theses, especially the substantial influence of Pico della Mirandola's vehement criticism of astrology-astronomy on the genesis of Copernican cosmology, were contested. A controversy ensued, which did not fully subside until today. See Swerdlow 2012; Westman 2013b; Shank 2014a; Westman 2014; Shank 2014b; Kokowski 2024b.

[3] The same objective was pursued by other papers presented at the 'Copernicus and Astrology' conference: Kokowski 2024b and Konarska-Zimnicka 2024.

- Belief in the subject and strict adherence to the corresponding set of assumptions and axioms, as well as to the logical inferences made from them? Accordingly, we can, following Edward Rosen, ask 'Did Copernicus believe in astrology?[4] Did he accept its assumptions and axioms as well as the logical inferences made from them?' (**Q2**)
- Practicing the art professionally or at least regularly? It is well-known (e.g. see Borski, Kokowski 2021) that Copernicus evolved greatly during his life. Therefore, it makes sense to split this question in two: 'Did Copernicus practice astrology in his youth or student years?' (**Q3**) and 'Did a mature Copernicus practice astrology?' (**Q4**)

The questions **Q1**–**Q4** listed above are not novel, having been posed by numerous historians before. They do not constitute an exhaustive list for the declared topic either.[5] Yet, any other existing or potentially conceivable questions have been left beyond the scope of this article.

3. Commonly used arguments

Let us review the commonly used *pro en contra* arguments[6] and check what the corresponding facts are 'proving', i.e. which answers of the above-mentioned questions do they corroborate and to what extent.

3.1. Arguments *pro*—yes, Copernicus was an astrologer

3.1.1. Argument from contemporaries

There is no need to list all the astrologers of the 15th–16th centuries, since it has been abundantly done by many authors elsewhere.[7] Even the terms 'astronomy' and 'astrology' were often used then interchangeably. The purely mathematical part was often considered a necessary, albeit insipid, introduction to the prognostication or election procedures. The outbreak of the Black Death in Europe in the middle of the 14th century as well as the recurring epidemics following it might have further spurred the spread of astrological beliefs (according to Westman 2011, p. 25). Although religious-based opposition to the art did not disappear entirely, it lost much of its persuasive impetus. The same Christian rigorists who publicly criticized "judicial astrology" used the services of astrologers in private (Sarton 1948).

Considering this, are we justified to declare that Copernicus was an astrologer or at least shared the beliefs common to his zeitgeist? This is an attempt to produce a positive reply to **Q2** (**Q1** as well, sometimes) and it constitutes a typical instance of an insecure inductive inference. Moreover, there are grounds to claim that it leads to an incorrect conclusion. After all, Copernicus

[4] This is literally the question which Edward Rosen posed in 'Copernicus and the Scientific Revolution' pp.110–111. Naturally, we will never have direct access to Copernicus's beliefs and they could have evolved during his life. This is why we rephrased the question as 'Did he accept its assumptions and axioms as well as the logical inferences made from them?'

[5] E.g. Professor Robert Westman proposed to ask 'Where did Copernicus stand in Piconian controversies?' See Westman 2013a, p. 51.

[6] The enumeration below does not pretend to be exhaustive either.

[7] 'Copernicus lived in an era when astrological ideas permeated academia' (Gingerich 2004, p. 186) is just one of many oft-cited dictums.

was a black swan among his contemporaries. Although none of them tried to shake some of the most fundamental ideas of the time, Copernicus did.[8]

3.1.2. Argument from teachers

Obviously, Copernicus also had astrologically minded teachers. The following persons are most often mentioned in this regard:

- Albert Brudzewski (ca.1445–ca.1497). There is no direct evidence of Copernicus being a pupil of this prominent Polish astronomer but an early biographer of Copernicus, Jan Brożek (1585–1652), claimed Copernicus was Brudzewski's student. Although Brudzewski had already stopped lecturing on astronomy at the Jagiellonian university by the time Copernicus enrolled there (Morawski 1900b, pp. 72ff, 177ff, 311ff), they could have met elsewhere in Kraków. Brudzewski most probably held firm astrological beliefs, as evidenced by his extant writings (Rosińska 1984, *passim*; Markowski 1990, pp. 7–17), nativity judgments (Juste 2021, pp. 587–589) and charts cast by him (A. Birkenmajer 1937).
- Dominico Maria Novara (1454–1504). Copernicus resided at his house during his student years at Bologna (1496–1500). Being a professor at the university, Novara was obliged to issue the annual astrological prognostications, some of which are extant (Bònoli et al. 2012). Although Rheticus (16 February 1514–4 December 1574) famously tried to portray Copernicus as a collaborator rather than a pupil of the Italian astronomer in his *Narratio Prima* (1540), a certain formative influence exercised by Dominico Maria on Copernicus is quite plausible.

Other people are spoken of somewhat less often and more briefly. The Jagiellonian university of Kraków had a long tradition in astronomy-astrology. A *Collegium Stobneri* of mathematical astronomy was established in about 1405, and in about 1450 the astrologer Marcin Król of Żurawica (ca. 1422–1460) established an additional chair dedicated entirely to astrology (Morawski 1900a, pp. 399ff, 402, 404). A student of Król Marcin Bylica of Olkusz (1433–1493) became famous as a court astrologer of Mattheus Corvinus, advising the mighty king on the most propitious moments to launch assaults on the enemy's castles (Hayton 2010) and so on. His astronomical instruments, which were advanced at the time, were donated to the *alma mater* and the solemn occasion of their translation doubtless inspired much admiration from the young Copernicus (L.A. Birkenmajer 1892). Copernicus likely heard multiple stories of his astrological feats as well.

Even before Copernicus had enrolled at the Kraków university, in ca. 1488–1491, he might have been[9] a student of Mikołaj Wodka of Kwidzyn in Włocławek. Extant writings of Mikołaj clearly reveal his astrological convictions, see Markowski 1990, pp. 158–160.

By the time Copernicus entered the Jagiellonian university, its fame as an outstanding centre of astrological knowledge extended well beyond the Polish borders (Morawski 1900b, Rybka

[8] See also the counterargument presented below in subsection 3.2.3.

[9] According to L.A. Birkenmajer 1926. An alternative version portrays Copernicus as a pupil of the Brethen of the Common Life who established a school in Chełmno (Barycz 1953, p.19).

1975; Konarska-Zimnicka 2018). Among the numerous professors reading *viva voce* on astrology two can be singled out—John of Głogów (ca. 1445–11 February 1507) and Michael Falkener of Wrocław (ca. 1450 or 1460–1534). The former, a great polymath scholar, wrote an astrological summa which, despite never having been printed, survived in dozens of handwritten copies and spread to Rome and Nuremberg.[10] He was the person who made the famous astrological prediction of a 'black monk' causing a great commotion, worse than the Hussite heresy–commonly identified as Luther (Szczegóła 1967, p. 46). The latter, known to deliver lectures on astrology during Copernicus's stay in Kraków, issued several annual astrological prognostications and wrote introductions to almanacs, see Markowski 1990, pp. 125–128.

Are we then justified to deduce from the abundance of teachers-astrologers that Copernicus was an astrologer as well? This is also an attempt to produce a positive reply to **Q2** and **Q1**, and again, it is a typical instance of an insecure inductive inference. Just one additional implicit premise has been added–persuasions of teachers are transmitted to their students, but this might well be false in the case of Copernicus.

3.1.3. Argument from books

As a keen and attentive reader, Copernicus was exposed to a wealth of books containing astrological lore, praising astrology, or relying on astrological assumptions. Moreover, while a student at Kraków, most likely in 1493 (see L.A. Birkenmajer 1900, pp. 26ff and 1924, pp. 337ff, 65) young Copernicus acquired printed copies of the *Alfonsine Tables*, Regiomontanus's *Tabulae directionum et profectionum*, which he bound in a single volume (currently Copernicana 4), and Haly Albohazen's *In iudiciis astrorum* (which he bound together with Euclid's *Elementa geometriae* in a different volume; currently Copernicana 6).[11] The *Alfonsine Tables* were used to calculate the planetary positions for an arbitrary date, which made them particularly suitable for astrology.[12] The tables of Regiomontanus were specifically designed to facilitate calculation of the cusps of the astrological houses. The third book was a translation from Arabic of a comprehensive astrological treatise. This indicates that, at the time, Copernicus was either genuinely interested in astrology or, at the very least, tried to catch up with the university curriculum. There is no evidence that Copernicus consequently read astrological books. However, he likely had access to the library of Novara, which undoubtedly had some astrological literature, while residing at his house in 1496–1500.[13]

These facts and speculations corroborate a positive reply for **Q3** and to a somewhat lesser degree–for **Q1**. However, it would be hasty to extend this argumentation to support **Q2** since then the argument would have to rely on an implicit premise—the books determine the ideas of their readers, and this might well be false in the case of Copernicus.

[10] See Markowski 1990, pp. 62–67. NB: the third part of his treatise can be found as '*Tractatus integer de nativitatibus'* in manuscript BnF, lat. 7395–an astrological notebook of Nicolaus Gugler, a pupil of Rheticus and his travel companion during the visit to Nuremberg in 1538. See the description of this MS by David Juste at https://ptolemaeus.badw.de/ms/172.

[11] See Czartoryski 1978.

[12] However, purely astronomical usage was also possible. See chapter 6 below.

[13] This is one of the key observations of Westman (2013).

3.1.4. Argument from medicine

Copernicus presumably studied medicine[14] in Padua and he is known to have served as a physician to several Warmia bishops upon returning to Poland. He likely had some medical practice in his town of residence, Frombork, as well. The so-called astrological elections were commonly used at the time to calculate the most propitious time for conducting medical procedures, such as bloodletting. Could Copernicus obviate the established way? Yet again, it is a clear example of an inductive reasoning trying to ‘prove’ **Q4**, and once again, it is not persuasive. We clearly need more than that, but none of the numerous medical annotations of Copernicus alludes to astrology. Similarly, astrology is not mentioned in the extant letters of the bishops describing the medical treatment they received from Copernicus.

3.1.5. Argument from the letter of Wapowski

On 15 October 1535, Bernard Wapowski (1475–1535), a lifelong friend of Copernicus and secretary to the Polish king Sigismund, sent a letter[15] to Sigismund von Herberstein (23 August 1486–28 March 1566), a diplomat in service of the Habsburgs. The letter was meant to accompany an almanac calculated by Copernicus according to his new theory, and it amounted to a request to publish and spread said almanac in Vienna. The planetary longitudes had to be supplemented with the astrological aspects between the planets, as the genre dictated. Unfortunately, however, not all of them were written by Copernicus (*aspectus omnes non perfecit).* Moreover, Wapowski discovered some incorrectly written aspects. He ascribed the first issue to his own lack of time when he came to fetch the almanac and the second to the mistakes made by the copier in haste (*transcriptori festinanti*). A mature Copernicus calculating some astrological aspects is probably an established fact but **Q4** is a *non sequitur* from it. Apparently, Wapowski simply tried to preserve the reputation of his friend whom he praised as a superb astronomer (*maximus mathematicus*) and whose achievements he actually tried to publicize.[16] What made fetching the almanac so urgent? It is just as plausible to suggest that Copernicus simply did not think the astrological aspects to be important and this is why he did not complete them. What made the almanac so precious that it required an additional person to copy or transcribe it, again, in a hurry? Why were the copying mistakes made with the astrological aspects only, not affecting the planetary positions? It is just as plausible to suggest that it was Copernicus who made the mistakes with the astrological aspects, once again, because he did not consider them to be important.

3.1.6. Argument from the *Narratio Prima*

From the first and the only disciple of Copernicus—Georg Joachim Rheticus—we have several extant writings which leave no doubt about his belief in astrology. The most relevant for our purposes, namely, the *Narratio Prima* also contains an astrological fragment. Rheticus’s idea was

[14] We are sure about his intention to study medicine in Padua (see Biskup 1973, p. 60, no. 38). However, he seems to have left the university without obtaining his degree. For arguments to the contrary see Kokowski 2024a.

[15] See CGA IV, pp. 186–187.

[16] Copernicus was reluctant to publish his work (in a Pythagorean fashion) as he explained himself in the dedication letter to the Pope Paul III (CGAII, pp. 3–4). Spreading the calculated from the hidden theory planetary positions was the only thing he agreed to do.

very ambitious and clearly inspired by the desire of Melanchthon and his surrounding circle of people to explain history by stars (see Lotito 2019). He suggested that a period of trepidation in Copernicus's theory correlated with major historical events and even bravely proceeded to predict the future. The *pro* argument then proceeds to claim–since Rheticus wrote the *Narratio Prima* while visiting Copernicus, his astrological speculations must have been approved by the *Dominus Praeceptor*. It is a persistent argument which can be traced at least to Dreyer (1906).

Unfortunately, this short and simple narrative does not reach its intended goal either, which is affirming both **Q2** and **Q4** simultaneously. Its problem is not just the lack of documentary evidence of the presumable approval of Copernicus.[17] The whole story is ripped out of its historical context. As we well know and as Copernicus himself explained in the dedication letter to Pope Paul III (CGAII, pp. 3–4), he refused to publish his work for a long time. His reasons were most likely dissatisfaction with the precision of his theory, the fear of being ridiculed, rebuked, or generally repudiated, getting involved in a controversy and some other possible considerations, e.g. he might have considered the idea dangerous for the unlettered humankind. As we saw in subsection 3.1.5, for some time he toyed with the idea of publishing only the ephemeris, concealing the underlying models. Further, if he decided to reveal the theory to Rheticus at all, it was because he wanted to follow the example of Pythagoreans who preferred to pass the philosophical mysteries '*non per literas sed per manus'*, i.e. not broadcasting them to everyone but passing them secretly to close friends. This is why he initially firmly refused to publish *De Revolutionibus*. This is why it would have been highly inconsistent for him to allow Rheticus to publish the *Narratio Prima* as well. If he genuinely wanted to allay his fears, then allowing Rheticus to test the waters by sending a private letter to Johannes Schöner (16 January 1477–16 January 1547) would be much more in tune with his convictions. The eventual commendatory opinion of this illustrious Nuremberg expert would then suffice to tip the scales in favor of publication. However, this was probably not an option for Rheticus, since Schöner was likely indifferent if not hostile to Copernicus's cosmology (see Maruska 2008).

Therefore, it is much more plausible to suggest that Rheticus, who wished to rehabilitate himself in Wittenberg[18] by discovering a second Ptolemy, and Tiedemann Giese (1 June 1480–23 October 1550), bishop of Chełmno at the time, who wished to save his friend Copernicus from the imminent persecution of Johannes Dantiscus[19] (1 November 1485–27 October 1548), hatched a plan together to force Copernicus to give up what they perceived as a stubborn attitude. Rheticus went to a publisher in Danzig (*nota bene*, the home city of the bishop Giese), undoubtedly supplied with enough money to edit the book. To save face in his relationship with Copernicus, he cleverly

[17] Edward Rosen, claiming that Copernicus neither approved, nor even saw *Narratio Prima* before publishing, used a different argument (see Rosen 1984, pp. 109–111). He pointed out to a mistake Rheticus made expounding Copernicus's theory, namely misquoting Regiomontanus's *Epitome* that "Arzahel", i.e. al-Zarqali, boasted having made 402 observations. This "402" was a misprint. "4or", i.e. *quattuor*, was in fact meant by Regiomontanus and that was clearly properly understood by Copernicus who adopted the Arabic method of making 4 observations of the Sun in the midpoints of 4 zodiacal signs. Had Copernicus seen the *Narratio Prima*, he, who did not make such mistake himself and was an expert reader of *Epitome*, would surely not allow it to go to press.

[18] He was involved in a scandalous story, causing an indignation of Martin Luter. See Kraai 2001.

[19] He was accused of having a sexual relationship with his female housekeeper. Besides, he, a Roman Catholic canon welcomed Rheticus the Lutheran, which was explicitly prohibited (Rosen 1984, p. 82).

decided to conceal not only his teacher's but also his own identity under 'a certain youth, studying mathematics' – a false humility which he dropped by the edition in Basel the very next year. He tried to create an impression in the text that he had acted completely in concert with the '*Doctissimus Dominus Schoner*', since he could not obtain his approval in any other way. Moreover, he 'blackmailed' Copernicus promising to publish a 'second account' of his work, i.e. effectively revealing the secret doctrine to the whole world. He never did it simply because the trick had worked. Copernicus, probably reluctantly, succumbed to the pressure. Hence, it is no wonder that Copernicus did not mentione Rheticus in his acknowledgements of *De Revolutionibus*.

3.1.7. Argument from annotations

During his life, Copernicus annotated quite a few books, which have survived until today.[20] Some of his marginalia, 7 to be precise (out of more than 400 authentic ones[21]), are of astrological character. Predictably, they are located in Haly Albohazen's *In iudiciis astrorum*. Recently, David Juste (2024) studied them thoroughly. Next to the 7 previously edited annotations, he found an additional 18 passages which Copernicus had underlined, marked, or titled. Juste demonstrated that the annotations showed Copernicus's profound knowledge of astrology. Apparently, he thoroughly comprehended not only Haly but also Ptolemy's *Quadripartitum* (*Tetrabiblos*). Furthermore, he used an additional unknown astrological source. Moreover, some of Copernicus's comments suggest that he did not just passively read Haly, but sought information regarding some people he had in mind, most probably having cast their nativities.

This evidence provides clear support for **Q1** and **Q3.** Regarding **Q2** and **Q4**, we should note that the Haly book was most probably purchased by Copernicus in 1493. David Juste also convincingly argued that all the annotations were made before Copernicus's journey to Italy in 1496. The annotations—with one insignificant exception—are concentrated in Books IV and V,[22] which deal with nativities. Hence, based on the evidence we can only conclude that young Copernicus likely learned some astrological precepts and tried to apply them in practice. This is something that can be expected from a keen student of astrology in Kraków university.

3.1.8. Argument from the letter of Apelt

On 8 April 1535 Johannes Apelt (1486–1536) sent a letter from Nuremberg to Albrecht of Brandenburg, the duke of Prussia (17 May 1490–20 March 1568), whom he used to serve as a chancellor.[23] The letter was meant to accompany a nativity and the *revolutiones* for three coming years calculated by Joachim Camerarius (1500–1574), a famous polymath and friend of Melanchthon. Although the gift had a clear astrological purpose, no astrological interpretation was provided. To obtain it Apelt advised Albrecht to avoid Johannes Poliander (1486–1541) by all

[20] The whole collection can be found online at www.derebus.nl/ca.aspx.

[21] The authenticity of the annotations is determined by paleographic experts and is rarely challenged. Peculiarly, Czartoryski (1973) expressed a doubt regarding the authenticity of the very same 7 annotations in Haly Albohazen's *In iudiciis astrorum*, but his opinion was later rejected by other researchers (see Rosińska 2002; Kokowski 2024; Konarska-Zimnicka 2024).

[22] There are 8 books in total in Haly Albohazen's *In iudiciis astrorum*.

[23] See CGAVI/1, pp.184–185.

means, and turn instead to someone else, e.g. to the "*alte thumherr zur frauenburg*", i.e. to Copernicus. Hence, argues David Juste (2024), Copernicus had the required knowledge to fulfill the task. Consequently, **Q1** and maybe also **Q4** are corroborated.

Historians are not unlike philosophers–the *modus ponens* of one of them becomes the *modus tollens* of the other. The logical structure of this *pro* argument is: knowledge implies fact, <Apelt knew that Copernicus was an astrologer> → <Copernicus was an astrologer>. L. A. Birkenmajer (1924, p. 238) reversed it: lack of fact implies lack of knowledge, <Copernicus was not an astrologer> → <Apelt did not know much about Copernicus>. However, both inferences are inaccurate since we are not justified to claim that their premises are true while the proposition <Copernicus was an astrologer> is a *non sequitur* from <Apelt thought him to be an astrologer>.

To arbitrate in this case, we should first consider Apelt's motivation to mention Copernicus. In his letter, he insisted on keeping the matter secret from Poliander under the pretext that he followed a 'different art' from Ptolemy, Carion[24] and others. A poor relationship between Apelt and Poliander might be a more plausible reason. An appeal to avoid Poliander should then be seen only as a tacit charge of incompetence. This was Apelt's primary concern and he did not really care who would help the duke to foresee the future, provided it was not Poliander. Anyone else, including Copernicus, would be up to the job. NB: Apelt does not even call Copernicus by name. Was it because he did not know or forgot it? Most likely, Apelt merely knew that some canon in Frombork was dealing with astronomy and naturally presumed that he was learned in astrology as well. Nevertheless, he was probably right in that—**Q1** has been corroborated again.

3.2. Arguments *contra*—no, Copernicus was not an astrologer

The historians supporting negative answers to questions **Q1–Q4** stood on the high ground of scientific orthodoxy, while their opponents had to attack them with the multiple arguments mentioned above. Additionally, it is generally much easier to prove the existence of something rather than its non-existence, for a single established fact is sufficient for the former but even an abundance of evidence is insufficient for the latter. These reasons account for the relatively small size of this section when compared with the former one.

3.2.1. Argument from extant writings

With the exception of the above-mentioned annotations (see subsection 3.1.7; they were probably made by young Copernicus following the university curriculum), there is no reference to astrological matters in Copernicus's extant writings, letters, or marginalia. Starting from his *Commentariolus* (dated by some researchers as early as 1503—see Borski, Kokowski 2021) and up to *De Revolutionibus* (which might have been completed as late as 1542), he is consistently silent on the subject. Neither his own annotations of medical nature nor descriptions of his medical practice written by others refer to the astrological 'elections'. Does this mean at least **Q4** and maybe also **Q2** have been refuted?

[24] Johann Carion (22 March 1499–2 February 1537) was at that time suspected in dabbling in black magic. See Lotito 2019.

Not *per se*. *Ex silentio* arguments are notoriously weak. *Commentariolus* is probably at least partially modeled after the 'Elements' of Euclid, and *De Revolutionibus* is certainly and fully modeled after the 'Almagest' of Ptolemy. These models are, respectively, purely mathematical and astronomical works. Therefore, you would not expect to find any astrological deviations in them. The other works of Copernicus are too far from the subject. His correspondence—with the single exception of a celebrated letter to Wapowski (see CGAIV, pp. 113–162—its subject is purely astronomical)—is primarily concerned with private or political matters.

3.2.2. Argument from lack of evidence

No cast nativities, other astrological charts, or textual prognostications are attributed to Copernicus. With the single exception of Rheticus, we are also unaware of any professional astrologers surrounding or, *a fortiori*, influencing a mature Copernicus.[25] Excluding the above-mentioned volumes purchased by Copernicus in 1493 (see subsection 3.1.3), no books of astrological content are known to be owned or read by him. Let us check if this line of reasoning can disprove **Q4** or **Q2**.

Nativities or prognostications, unless intended for princes (and Copernicus was not a court astrologer) or publishing (and Copernicus was not a university professor), would likely be discarded after use. We are certainly unaware of many books that Copernicus used to read and all the people with whom he kept contact. Trying to infer anything from our ignorance is to commit an *ad ignorantiam* fallacy.

3.2.3. Argument from 'black swan'

Perhaps the strongest of all *contra* arguments belongs to the domain of pure reason.[26] Copernicus was a 'black swan' among his contemporaries, proposing and defending a hypothesis which contradicted a lot of 'truths' of the established paradigm. The worldview combining Christian dogma with Aristotelean philosophy was quite a coherent set of beliefs, even by modern standards. Astrological lore constituted its subset, and not an insignificant one. It is modern astrology that seemingly does not care how the entirety might work. The typical[27] medieval scholar, on the contrary, saw a big holistic picture, where, as explained by the great Ptolemy in the *Tetrabiblos* (Ptolemy 1940, pp. 4ff), the stars furnished by their revolutions heat, moisture, dryness, and cold (or 'species' as scholastics preferred to call them), which penetrated all the way down to the sublunar world, thus influencing both the weather and the destinies of people quasi-mechanistically. A less commonly accepted—but popular in the Renaissance—grand narrative (inspired by Neoplatonism) imagined souls on their pre-birth fall-down route acquiring their qualities from the planetary spheres and then returning the borrowed things to the Lord on their postmortem way back to heaven (see Macrobius 1990).

[25] Bernard Wapowski and Marcin Biem (ca. 1470–9 November 1540) are sometimes mentioned in this context as well. However, the former was not a professional astrologer and regarded Copernicus as an authority in these matters. The latter became a magister of theology in 1517, and we have no evidence of his contacts with Copernicus since then.

[26] We are not aware of anyone explicitly formulating it in this manner.

[27] There were alternative mystical interpretations as well.

All these and many other astrological beliefs might have been no longer tenable in a geokinetic Universe envisioned by Copernicus. E.g. changing material 'species' going 'down' to the light rays coming from everywhere might have been unacceptable to him[28] because he might have been deeply entrenched in the Aristotelean tradition as Goddu (2010) would like us to believe.[29] Consequently, if Copernicus had firmly held astrological beliefs, as a consistent systems thinker, he would have had to perform a considerable amount of mental work to find an alternative explanation, something akin to what he did by incorporating elements of Pythagorean-Platonic physics, fashionable at the time, into his worldview (see Knox 2005; Kokowski 2024b). However, if his astrological beliefs were superficial, we would expect him to behave exactly as he did—he simply ignored the matter. It has been acutely noticed by some historians[30] that Copernicus generally preferred to be silent on matters about which he was unsure (such as the physical construction of the heavenly orbs or the infiniteness of the universe). In conclusion, let us note that it does not prove (to claim that would be an 'affirmation of the consequent' logical fallacy) but corroborates a negative answer to both **Q2** and **Q4**.

4. Tools

Copernicology should probably abandon the hope of genuinely new evidence being unearthed in the foreseeable future. Nevertheless, it does not mean that we should stop analyzing the existing facts. Modern technology, especially computer technology, offers possibilities to uncover formerly hidden subtle clues. With this purpose in mind, two new software tools have been developed.

4.1. Database of Copernicus's annotations

Copernicus's annotations indubitably represent a window into the mental world of the great scientist. Many historians contributed to finding, transcribing, and interpreting them. Some researchers, among whom Paweł Czartoryski stands out (Czartoryski 1978), tried to assemble and organize the available information. A detailed list of annotations has also been carefully elaborated in the printed encyclopaedical editions (CGAIV and V). However, the window remained, if not fully shut, then barely ajar. Browsing Copernicus's marginalia typically involved alternating between the transcriptions and the image, and it remained an arduous, time-consuming task.[31] Moreover, some newly discovered annotations have barely been catalogued (Garwoliński 2016).

A computer database of Copernicus's annotations seemed an appropriate solution. Now, it has not only been built but also been made available for everyone online, at https://www.derebus.nl/ca.aspx.[32] This tool enables to study the issues at hand holistically, considering not just some but all of Copernicus's marginalia as a whole. The improvement in research speed is not the only potential benefit of the solution. Digitally available information

[28] E.g. for Aristotle the light was 'neither fire nor any kind whatsoever of body nor an efflux from any kind of body'. See *De Anima*, Book II, chapter 7.

[29] This conclusion is not universally accepted – see Michał Kokowski (2024b).

[30] E.g. by Edward Rosen (1984, p. 59); Michał Kokowski (2024b). This conclusion, among other things, is supported by Copernicus's own words in '*De Revolutionibus*' (book 1, cap. VIII, CGAII, p. 19): '*Siue igitur finitus sit mundus, siue infinitus, disputationi physiologorum dimittamus*,' as pointed out by Prof. Kokowski.

[31] As recognised by Dilwyn Knox in a private communication.

[32] The features of the online database have been discussed in detail in Calma and Borski (2024).

makes the eventual application of AI, *viz.* neural networks technology, a real possibility. If successful, it can finally separate the authentic annotations reliably from the spurious ones and perhaps even order them by date—a long-time desideratum of every Copernicologist.

4.2. Historical astrology toolkit

One of the major premises of astrology presumes unprecedented data compression. Just a few bits, coding the dates of events, are supposed to contain a huge amount of information, e.g. for nativities—character traits of people, events of their future life, and so on. The task of practitioners of the divine art was simply to properly extract that information. The task of the modern historians of science is to recreate and follow their procedures. With the historical astrology toolkit, we can also extract information, albeit of a different kind. We are not only able to cast astrological charts in 16th century fashion, but also deduce important details regarding historically preexisting charts. These details include:

- Which tables or their derivates (*Tabulae Resolutae* or ephemeris) were used to cast the charts. In the case of Copernicus, the *Alfonsine* or *Prutenic Tables* are relevant for our purposes, since no other tables[33] were available in Europe in the 16th century.
- Which astrological house system was used to cast the chart. Next to the Regiomontanus system, the most popular at the time, the Campanus, Alcabitius, Porphyry, and the so-called equal house systems were the feasible possibilities.
- What calculation mistakes (if any) were made. NB: some of these mistakes were caused not by negligence but by the desire of astrologers to save time. Rounding the numbers or using some approximating tools (such as the astrolabe) substantially reduced the precision of the chart. This in turn betrays the importance of the chart for the astrologer or lack thereof.
- The most probable latitude of [34] the place for which the chart had been cast. This information is directly available from the astrological houses.
- The most probable longitude[35] of the place for which the chart had been cast. This information might be available if the Moon's longitude was calculated with minute precision.
- If the inscription of the chart includes the time, we can check whether the equation of time has been taken into account, i.e. whether the time provided is LAT or LMT.

[33] The other tables, such as those of Bianchini or Gmunden, were ultimately also derivates of the *Alfonsine Tables*.

[34] It does rely on the previous determination of the astrological house system.

[35] It does rely on the previous determination of the tables used. The *Alfonsine Tables* were prepared for the Toledo meridian, and the *Prutenic Tables* were prepared for the meridian of the Prussian Koenigsberg. NB: the longitudes, unlike latitudes, were much more difficult to ascertain. They differed widely from the modern values for certain places. Nevertheless, the historically accepted values can be consulted (see Dobrzycki 1998).

- Which planet was most likely considered the hyleg. Two algorithms were popular at the time—per Ptolemy and per the 'common opinion of the astrologers'.[36]
- Whether the chart was likely rectified, and if so, with which rectification algorithm. The so-called Trutine of Hermes and Animodar were the most likely options at the time.[37] A peculiarity of both rectification methods is that the possible rectification times are few and far between (at more than one-hour distance from each other for the Trutine and even more than that for the Animodar), serving as a sort of attractor to the unrectified times fed into the algorithm.[38] Hence, if the time of the chart is close to one of these attractors,[39] the probability of a coincidence is negligible, and we can conclude that it has been rectified. Otherwise, if it is far from the attractors, the chart has most probably not been rectified (with the Trutine or Animodar).

Perhaps what makes the tool even more valuable for historians is its ability to scan a wide range of dates. While a medieval scholar had to spend hours casting a single chart, it can be calculated in just a fraction of a second with the new software. Consequently, certain properties of the tables (e.g. their precision for whole centuries) can be established.

Plans have been made to make the tool available on the Internet. However, only an offline version is currently available.[40] Here is a screenshot of the software:

[36] Per the astrological summa of John of Głogów. See manuscript BnF, lat. 7395, 291^{v} ff.

[37] It is only these algorithms that John of Głogów explicated in his astrological summa. See manuscript BnF, lat. 7395, 152^{r} ff.

[38] The major postulate of the Trutine is that <the Ascendant at nativity> = <the Moon at conception time> and <the Ascendant at conception> = <the Moon at nativity>. Since the conception day is rarely known, it is calculated from the nativity in a way that ensures the Moon on that day is roughly at the position of the Ascendant at nativity. It can be rigorously proven that these conditions imply the rarity of the possible rectified times. The Animodar starts from the choosing of the so-called almuten, normally a planet having the most 'dignities' at a certain point of the zodiac (longitude of the last syzygy before birth). The calculation of the rectified time is then a simple routine. Even though the choice of almuten depends on the qualitative judgement of an astrologer, there are just 7 planets available and, consequently, just 7 potentially rectified times.

[39] A gap of a few minutes is possible owing to the eventual rounding.

[40] The source code can be supplied on request.

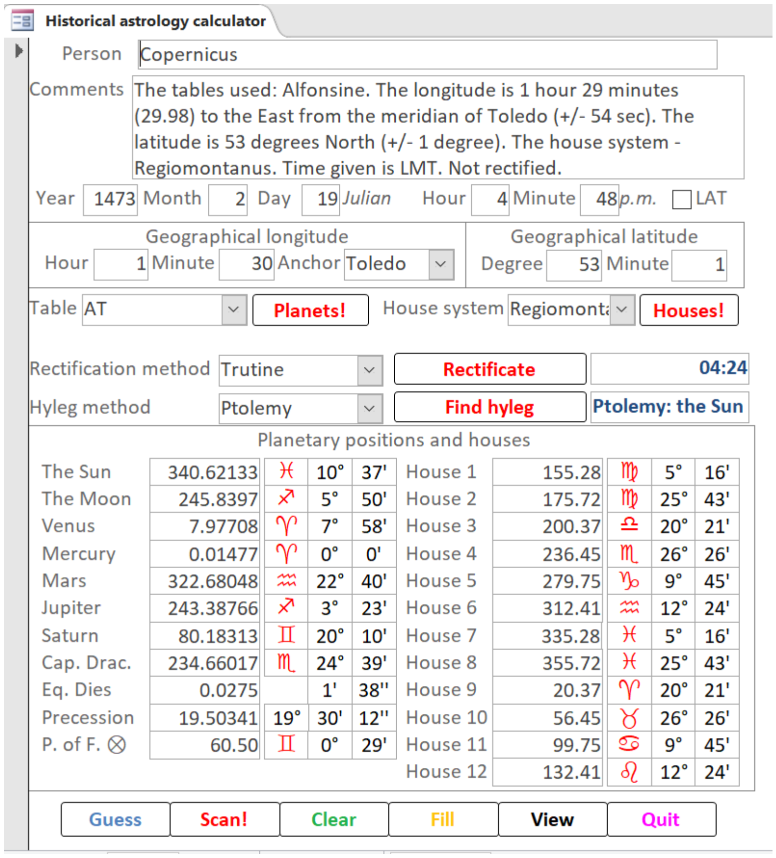


Figure 1. Historical astrology calculator

5. Argument from 4:48 p.m.

Copernicus belonged to an epoch when precise time-keeping devices were rarely kept at home. Life was usually regulated by sunrise, sunset, and the church bells. Perhaps the birthtime of a prince whose parents were obsessed with astrology could be expected to be recorded with minute precision. However, Copernicus was born into a family of a pious copper merchant, having connections to Dominicans, who were typically hostile towards astrology. This is why it is very likely that Barbara, the mother of Copernicus, could merely relate to her son something like 'you were born a few minutes after sunset' or 'roughly an hour before vespers'. This is why Copernicus's excessively exact birthtime of 4:48 p.m. (which appears in several private collections of nativities as well as in printed editions of the 16th century) has long attracted the attention of historians. L.A. Birkenmajer, having observed this peculiarity, chose to avoid commenting on it (1900, pp. 406–412). Noel Swerdlow and Otto Neugebauer suggested the first plausible hypothesis, acutely noticing that 4:48 hours constituted exactly one-fifth of one 24-hour day (Swerdlow, Neugebauer 1984, p. 454).[41] However, this obviously could have been just a coincidence. An alternative hypothesis at hand is an astrological rectification.[42] Indeed, the most

[41] Swerdlow and Neugebauer erroneously expressed this fact as 0;20 in a sexadecimal instead of decimal notation. 0;12 is the correct notation.

[42] E.g. it has been expressed by Gingerich (2004, p. 187).

important for the purposes of prognostication, namely, the ascendant, the midheaven, and the cusps of the houses, must be ascertained with utmost precision. Moving with an average speed of a sign per 2 hours or a degree per 4 minutes, their positions greatly depend on the exact time of birth, and it has been supposed that the missing information could and should be restored by rectification.

For a person strongly believing in astrology, their own nativity is a subject of priority deserving much reflection. For example, it is unsurprising to find a carefully rectified birth chart of Rheticus in BnF, lat. 7395 (f. 326^{v}), most probably calculated by him and copied by his pupil Nicolaus Gugler. Did Copernicus do the same? Alternatively, given that it could have been only Rheticus who spread information about his birthtime, could it have been Rheticus (or some of his Wittenberg/Nuremberg friends) who rectified the nativity of his *Dominus Praeceptor*? To evaluate all these possibilities, let us turn *ad fontes*.

5.1. The sources of 4:48 p.m.

Copernicus has been typically mentioned in printed astrological editions which include a catalogue of birth dates of illustrious people. He was also regularly included in the private handwritten collections of nativities.

5.1.1. The printed sources

The following list, although perhaps not exhaustive, is ordered chronologically:

- Caspar Peucer (6 January 1525–25 September 1602), a prominent member of the Melanchthon circle and a pupil of Rheticus, included the following information in his '*Elementa doctrinae de circulis coelestibus, et primu motu*' 1551 edition (Wittenberg) under '*Series astrologorum a primis patribus ad nostrum seculum usque, id est ad annum a nato salvatore domino nostro Ihesu Christo 1550*':[43]

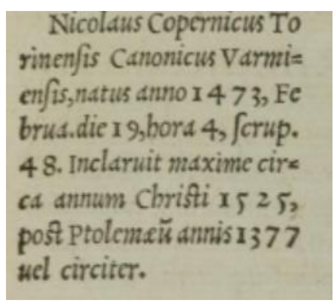

Nicolaus Copernicus To
rinensis Canonicus Varmi=
ensis,natus anno 1473, Fe
brua.die 19,hora 4, scrup.
48. Inclaruit maxime cir=
ca annum Christi 1525,
post Ptolemæũ annis 1377
uel circiter.

Figure 2. The birthtime of Copernicus is noted by Peucer as 4 hours 48 minutes

- Francesco Giuntini (1523–1590), a Florentine theologian and astrologer, included Copernicus in his '*Speculum astrologiae*' 1573 edition (Lyon). Copernicus is mentioned twice in the section *Calendarium Astrologicum* (both times under 19 of February). First on f. 20v: '*Nicolaus Copernicus Torinensis Canonicus Varmiensis, natus anno 1473 hora 4*

[43] Translation: A list of astrologers from the first fathers until our century, i.e. until A.D. 1550. See https://digi.ub.uni-heidelberg.de/diglit/peucer1551/0033/image,info page 31.

min. 48 post meridiem'. Then on f. 292r: '*Nicolaus Copernicus nascitur anno Christi 1473 minutis 48, post quartam horam pomeridianam'*.

- Johannes Garcaeus (1530–1574), a German theologian and astrologer, used Copernicus's nativity to illustrate an astrological precept, *viz.* the trine of Mercurius and the Moon, in his '*Astrologiae methodus*', *postmortum* 1576 edition (Basle):

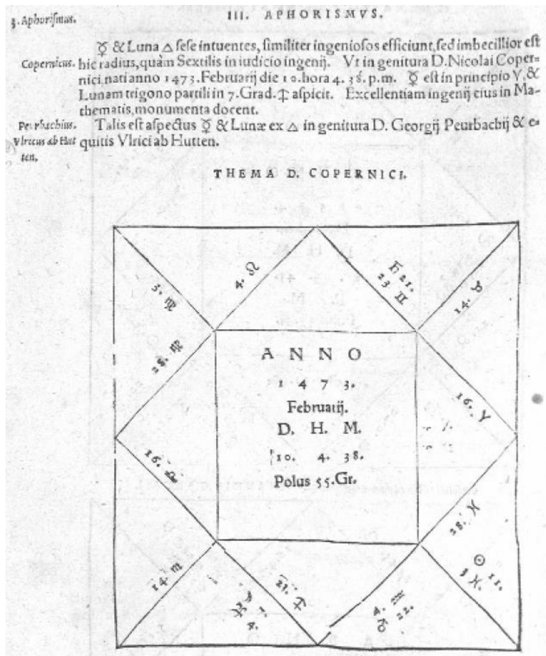
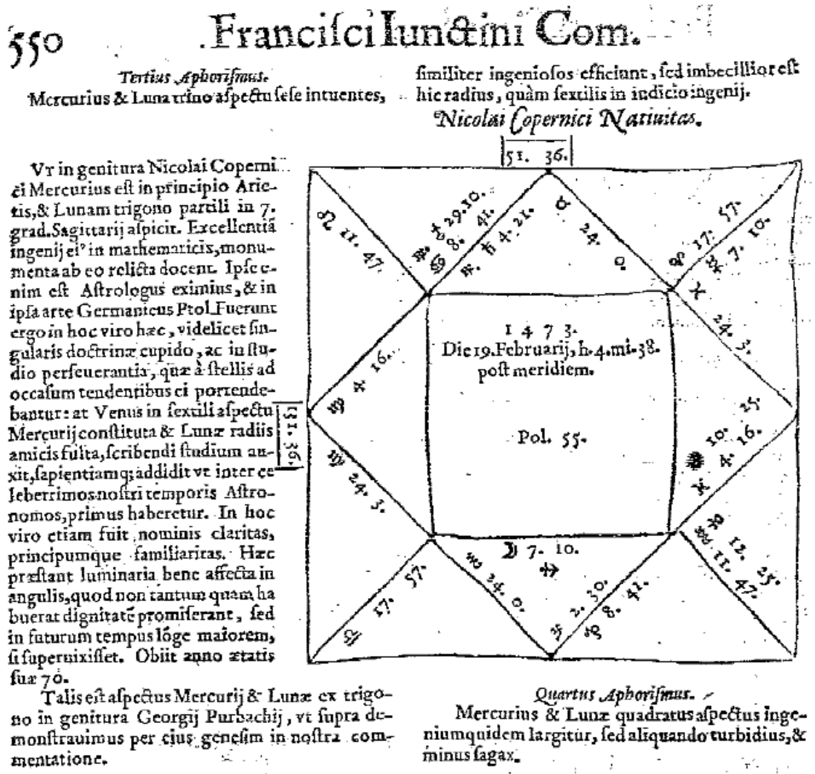


Figure 3. A birth chart of Copernicus cast by Johannes Garcaeus

The inscription '10 February' is misleading—it is a misprint; the nativity is cast for the 19th of February (judging from the locations of the Sun and the Moon). Not much attention should be paid to the indicated time of 4:38 p.m. either, since the Ascendant and the Midheaven point to around 7 p.m. In general, the chart is very imprecise (no minutes, 55 degrees latitude instead of 53, very rough rounding, or even calculation mistakes), and it was clearly used merely as an illustration of the validity of the author's *aphorismus* that Mercury and the Moon looking to each other from a trine produces geniuses. Next to Copernicus, the same aspect was allegedly found in the nativities of Georg von Peuerbach and Ulrich von Hutten.

- In a new edition of his '*Speculum astrologiae*' of 1581 (Lyon), Francesco Giuntini also included a nativity of Copernicus with a short interpretation (p. 550). It clearly depends on the above-mentioned publication, illustrating the same *aphorismus* and borrowing from Garcaeus not only the wrong time but even whole sentences verbatim:



550 Francisci Iunctini Com.

Tertius Aphorismus.
Mercurius & Luna trino aspectu sese intuentes, similiter ingeniosos efficiunt, sed imbecillior est hic radius, quàm sextilis in iudicio ingenij.

Nicolai Copernici Natiuitas.

Vt in genitura Nicolai Copernici Mercurius est in principio Arietis, & Lunam trigono partili in 7. grad. Sagittarij aspicit. Excellentiã ingenij ei' in mathematicis, monumenta ab eo relicta docent. Ipse enim est Astrologus eximius, & in ipsa arte Germanicus Ptol. Fuerunt ergo in hoc viro hæc, videlicet singularis doctrinæ cupido, ac in studio perseuerantia, quæ à stellis ad occasum tendentibus ei portendebantur: at Venus in sextili aspectu Mercurij constituta & Lunæ radiis amicis fulta, scribendi studium auxit, sapientiamq; addidit vt inter celeberrimos nostri temporis Astronomos, primus haberetur. In hoc viro etiam fuit nominis claritas, principumque familiaritas. Hæc præstant luminaria bene affecta in angulis, quod non tantum quam habuerat dignitatẽ promiserant, sed in futurum tempus lõge maiorem, si superuixisset. Obiit anno ætatis suæ 70.

1 4 7 3. Die 19. Februarij, h. 4. mi. 38. post meridiem.

Pol. 55.

Talis est aspectus Mercurij & Lunæ ex trigono in genitura Georgij Purbachij, vt supra demonstrauimus per eius genesim in nostra commentatione.

Quartus Aphorismus.
Mercurius & Lunæ quadratus aspectus ingeniumquidem largitur, sed aliquando turbidius, & minus sagax.

Figure 4. A birth chart of Copernicus cast by Francesco Giuntini

The only remarkable details to report here are the houses calculated with minute precision, albeit for the wrong time (4:38 p.m.) and incorrect latitude (55 degrees), and the planets, some of which are greatly miscalculated (it is conspicuous that Mercurius is forced to be in an exact trine with the Moon, probably with didactic purposes in mind).

5.1.2. The private astrological collections

Horoscopes of Copernicus are also available in private collections. According to David Juste,[44] about 10 of them exist. He also claims that some of these charts were cast earlier than the first of the above-mentioned printed editions. The one found in MS Leipzig, UB, IV.87 on f. 127r can be dated as early as 1543 and—*nota bene*—it has no reference to 4:48 p.m.:

[44] This and some other valuable information in this section was received from David Juste in a private communication. David Juste plans to write on this subject extensively, but he generously allowed us to publish the teaser.

Figure 5. A nativity of Copernicus in MS Leipzig, UB, IV.87, f. 127r

Instead, it states that the birth occurred ‘shortly after sunset’. The ‘day of Venus (i.e. Friday) *ante Cathedram Petri*’ does correspond to February 19. However, apart from the Ascendant and the Sun (it is indeed depicted under the horizon by choosing the appropriate time for the Ascendant, which corresponds to around 6:42 p.m.), there are no longitudes on the chart. Moreover, some planets, *viz*. Venus, Mercury, Mars, and Jupiter, are placed in the wrong signs. Could Rheticus have made such gross errors of calculation? Alternatively, was the chart used solely to determine an approximate time of birth?

The next by date (it can be dated 1546–1547) and perhaps the most important of our sources is the chart from Clm 27003 (München, Bayerische Staatsbibliothek) that is ubiquitous on the Internet. The nativity of Copernicus can be found on f.33v:

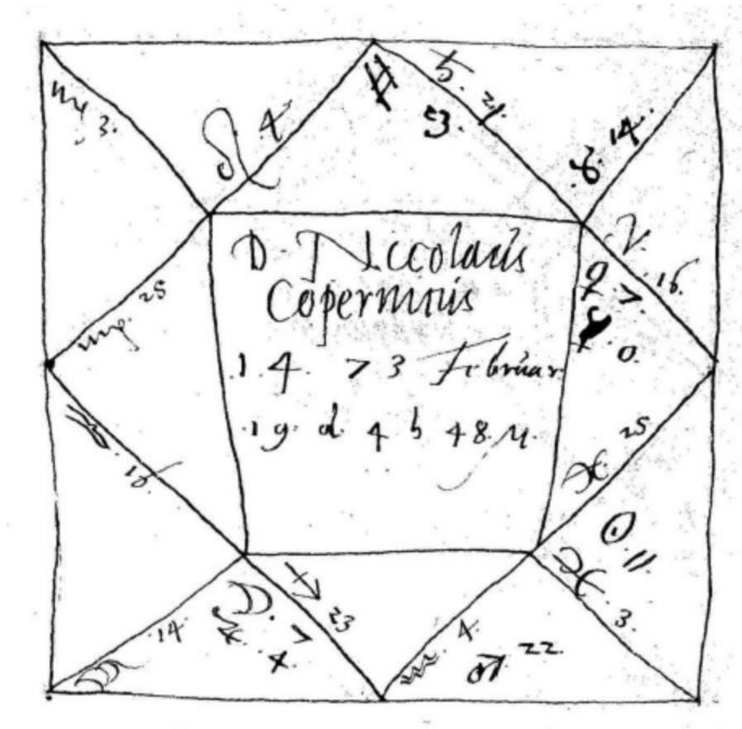


Figure 6. A nativity of Copernicus in Clm 27003, f. 33v

David Juste made a key observation here (see https://ptolemaeus.badw.de/work/96, under Note), noting that the handwriting belonged to none other than Erasmus Reinhold (22 October 1511–19 February 1553), outstanding astronomer and mathematician and author of the *Prutenic Tables*, who was very close to Rheticus. This chart explicitly mentions 4:48 p.m., but it has some peculiarities as well:

1. The chart is calculated with the *Alfonsine Tables*, but there is a difference of about 1 degree for Mars, Venus, Saturn, and Jupiter—and it probably has nothing to do with the rounding. A more accurate calculation would be expected from someone like Reinhold.
2. The actual time for which the houses are calculated (with the Regiomontanus system) is not 4:48 p.m. but corresponds to the LMT of around 6:42 p.m. (for the correct latitude of 53–54N). NB: The Ascendant is placed at Virgo 25, just like in the Leipzig MS.

   Subsequently, Reinhold must have realized that something in this chart was wrong, or he decided to elaborate it further,[45] and the result can be seen in MS Hamburg, Bibl. des Christianeums, R Ab 3 h/31.3, p. 179:

[45] Paying attention to this manuscript and identifying Reinhold's hand in it is, again, an intellectual achievement of David Juste.

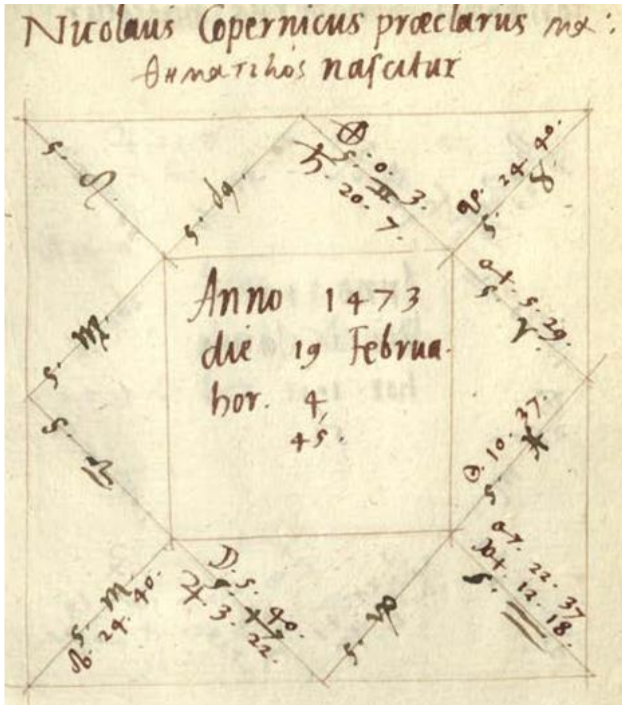


Figure 7. A nativity of Copernicus in MS Hamburg, Bibl. des Christianeums, R Ab 3 h/31.3, p. 179

This chart has a few peculiarities as well:

- The time is noted not as 4:48 p.m. but as 4:45 p.m. (rounded?), and the Ascendant at 5 Virgo corresponds to this time. With that time, the Sun is again just above the horizon.
- An equal house system is used (rather than the Regiomontanus system, the most popular at the time).
- All the planetary positions are calculated with minute precision using the *Alfonsine Tables*, including the Part of Fortune and the Lunar nodes, but there are strange exceptions:
  - Venus is about 2 degrees off the mark
  - Mercurius is placed in a wrong sign (one-and-a-half signs away)

5.1.3. The private inscriptions

As early as 1900 (pp. 411–412), L.A. Birkenmajer published information on two inscriptions he had found which also provide the exact date and time of Copernicus's birth without astrological charts accompanying it. One of them is especially significant, since it was made by none other than Achilles Pirmin Gasser (3 November 1505–4 December 1577), a close friend of Rheticus and an early admirer of Copernican cosmology.[46] In a handwritten addendum in his copy of *De Revolutionibus*,[47] he also insists on 4:48 p.m.: *Natus est hic Anno Domini 1473 die 19 Februarij hora 4.48'*.

[46] His *vita* is available in Burmeister (1970).

[47] The *Editio princeps* of 1543, which he received as a gift from Johannes Petreius, is currently in the Vatican library bearing the shelf marks Stamp.Pal.III.103(int.1) and Stamp.Ross.3759; see:

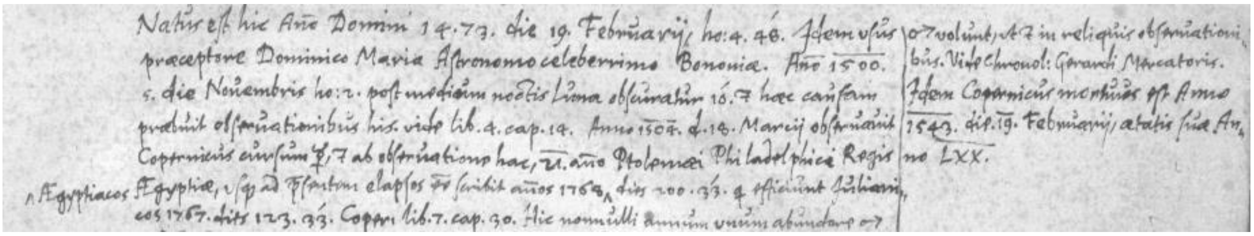


Figure 8. Gasser's annotation in his copy of *De Revolutionibus*

5.2. Discussion

It is not easy to make sense of all the above-mentioned conflicting facts and construct a plausible narrative covering all of them. Fortunately, we do not have to do that, since our only interest is to find answers to questions **Q1–Q4**. Examination of the charts reveals two conflicting traditions apropos of Copernicus's birthtime — 'shortly after sunset' (6:42 p.m. or with the Ascendant at Virgo 25, *cf.* Figures 3, 5, and 6) and '4:48 p.m.'[48] (with the Ascendant at Virgo 5, *cf.* Figures 1, 2, and 7).[49] *A priori*, both could have been the result of an astrological rectification. However, we can be quite sure that, unless a gross error was made in calculation, neither 6:42 p.m. nor 4:48 p.m. have been rectified with either the Trutine or the Animodar algorithms. The software described in section 4.2 clearly shows that, when calculating with the *Alfonsine Tables*[50] the following times were eligible for rectification:

- For the Trutine: 3:05 p.m., followed by 4:23 p.m., 5:44 p.m., 7:06 p.m., etc. Calculating with the Prutenic rather than with the *Alfonsine Tables*: 3:05 p.m., followed by 4:24 p.m., 5:45 p.m., 7:08 p.m., etc.

- For the Animodar: two 'planets' are the best candidates for the 'almuten', having the most 'dignities' at the longitude of the last syzygy (around 4 degrees of Virgo) —diurnal Mercurius (as being in its 'term') and the nocturnal Moon (as being in its 'triplicity').[51] For our range of possible '*aestimata*' birthtimes, the corresponding rectified times can be as follows: for Mercury around 4:17 p.m. and for the Moon 3:26 p.m. or 5:31 p.m. Calculating with the *Prutenic* rather than with the *Alfonsine Tables*: for Mercury around 7 p.m. and for the Moon 3:27 p.m. or 5:33 p.m.

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https://opac.vatlib.it/stp/detail/10114163. The annotation refers to Mercator's Chronologia, hence its *terminus post quem* is 1569. However, this book does not contain information on Copernicus's birth time and Gasser likely produced it from memory since he erred in some other details.

[48] 4:48 p.m. is too precise to appear in the manuscripts and books from nothing. It could have come only from Rheticus or Copernicus himself.

[49] We consider Figure 4 with 4:38 p.m. a mistake resulting from a misprint in Figure 3.

[50] Calculation with the *Prutenic Tables* does not produce anything in vicinity of 4:48 p.m. or 6:42 p.m. either.

[51] The other five 'planets' are less likely to be the almuten but still fail to produce anything in vicinity of 4:48 p.m. or 6:42 p.m.

It should be noted that Rheticus's own nativity, as found in BnF, lat. 7395 on folio 326v, has likely been rectified with the Trutine,[52] since the time written on the chart (15:26 p.m.) is quite close to the possible rectified time of 15:22 p.m.:

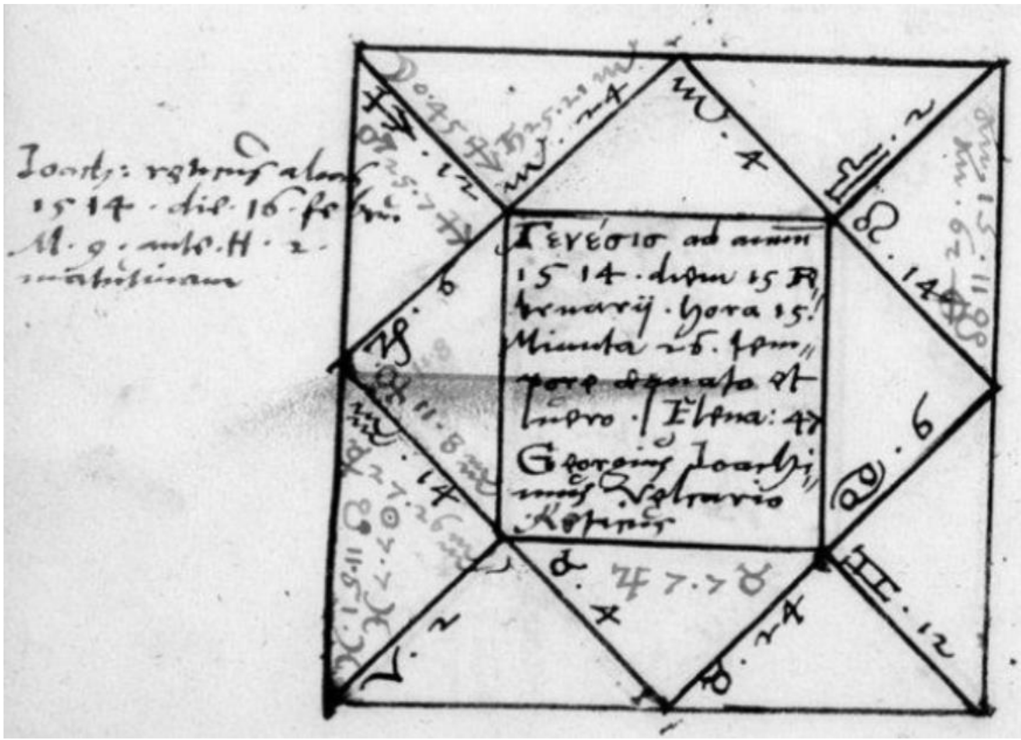


Figure 9. A nativity of Rheticus in BnF, lat. 7395 on folio 326v.

Logically, since '4:48 p.m.' (before sunset) and 'shortly after sunset' are mutually exclusive, the corresponding beliefs can hardly be held by the same person. Therefore, the only options are:

- P1: Copernicus's information: 'shortly after sunset'. Rheticus's[53] correction: 4:48 p.m.
- P2: Copernicus's information: 4:48 p.m. Rheticus's correction: 'shortly after sunset'.

Let us consider them in turn:

- If P1 is correct, then Copernicus never cared to rectify his own birth chart. Negation[54] of **Q2** immediately follows.
- If P2 is correct, then Rheticus found the birthtime chosen by Copernicus to be astrologically deficient. Therefore, negation of **Q2** follows in this case as well.

[52] The Trutine and Animodar were perhaps the most popular rectification methods at the time, but they were not the only ones. For example, the nativity could have been rectified 'by events', i.e. by trying to match the known major events in the life of a person with so-called astrological 'primary directions'. This method was favored by Johannes Schöner (1545).

[53] The correction could obviously have been proposed by some other astrologers in Rheticus's circle as well.

[54] A qualified negation; see the conclusion below.

The second option is more likely. Pushing the Sun under the horizon, i.e. making Copernicus's birthtime 'shortly after sunset', has a clear astrological significance—the all-important astrological 'hyleg' is no longer the Sun but Mercury. NB: In the nativity of Copernicus, Mercury is positioned at a special longitude of 0 degrees Aries[55] and has the trine aspect with the Moon, thus presumably producing geniuses, as judged by Garcaeus and Giuntini. With this consideration in mind, the exact time 6:42 p.m. loses its significance. The Ascendant could have been chosen to be at 25 degrees Virgo simply because this is the longitude of the cusp of the second house[56] in the 4:48 p.m. chart (see Figure 1). In contrast to 'shortly after sunset', there is no apparent astrological reason for why 4:48 p.m. could have been chosen as the birthtime of Copernicus. Although we cannot exclude the possibility of some other astrological considerations, the most plausible intention of all those early charts (*cf.* Figures 5, 6 and 7) was an astrological tinkering of Rheticus, Reinhold and their friends trying to reconcile Copernicus's nativity with what they knew about him.

5.3. 4:48 p.m.—number symbolism?

Rheticus would most likely have found Copernicus's choice to be astrologically deficient, if it were not astrological. Hence, having come full circle and dispelling some doubts on the way, we return to the above-mentioned hypothesis of Swerdlow and Neugebauer—the reason 4:48 was chosen was because it constitutes exactly one-fifth of the 24-hour day. A kind of number symbolism (not necessarily Pythagorean) might have induced Copernicus to prefer the number 5.[57] Copernicus is well known to have had some mystical inclinations, at least in his youth.[58] Additionally, it might not be coincidental that in the Copernican Universe,[59] the Earth received none other than the number five:

[55] As calculated by the *Alfonsine Tables*. It is placed a few degrees away according to Copernicus's own theory.

[56] That causes the Sun's original placement in the 7th house to be surely pushed under the horizon into the 6th house.

[57] One-fifth in the sexagesimal notation preferred by astronomers is 0;12. Copernicus could have seen a special significance in the number 12 as well.

[58] They are carefully collated in Wasiutyński (2003).

[59] *De Revolutionibus* book 1 chapter 10.

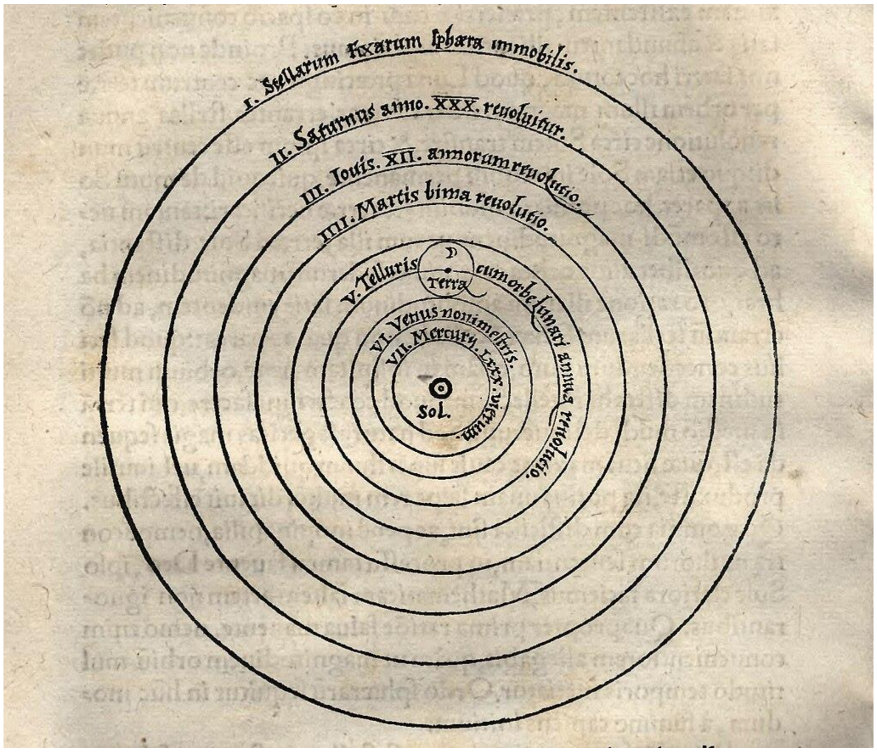


Figure 10. The Copernican Universe

To achieve this feat, Copernicus had to start counting from the sphere of the fixed stars in a striking violation of the then contemporary conventions.[60] We should not forget that number symbolism ruled supreme in his epoch. This is how Martianus Capella, whose work was most probably read eagerly by Copernicus (since he referred to him in *De Revolutionibus*—see CGAII, p. 23), stated it:

> The pentad comes next, the number assigned to the universe. This identification is reasonable, for after the four elements, the universe is a fifth body of a different nature. The number represents natural union, for it is the sum of numbers of each sex, for three is considered a male number, and two a female number. The number five is also called a recurrent number: whether it is joined with other odd numbers or with its own kind, it is always cropping up. For the product of five times five is twenty-five; five times three is fifteen; five times seven is thirty-five, and five times nine is forty-five. Then, too, there are five zones of the earth. In man there are five senses; the same number of classes of creatures inhabit the earth: humans, quadrupeds, reptiles, fish, and birds. Does anyone deny that the number five is also the diameter? For the perfection and circle of the decad is bisected by the semicircle of this number (Capella 1977, pp. 279–280).

[60] The total number of heavenly spheres in his drawing (owing to the combination of the Earth with the Moon) is also conspicuously 7. NB: the '*petitiones*' of the early opus *Commentariolus* also appear to have been slightly manipulated to produce the divine total of 7.

Associations with the mortal creatures, their procreation, and the Earth coupled with the cosmical and geometrical connotations might have captured the imagination of young Copernicus.

6. Argument from misprints

The volume containing an edition of the *Alfonsine Tables* (Venice, 1492) which Copernicus purchased in his early student years at the Jagiellonian university of Kraków has survived until today as Copernicana 4 in the Uppsala University Library. Copernicus kept this volume until the end of his life and made several annotations in it (CGAIV pp. 577ff). They are purely astronomical in nature in the modern sense of the word.[61] In general, tables like these are a universal tool that enable the calculation of planetary positions at an arbitrary time. Both astrological and astronomical usages are thus equally possible. It should be noted that a typical astrologer would rather use an ephemeris or almanacs, since they are precalculated, while calculation with the tables is quite an arduous task. However, the universality of the tables made them an indispensable tool when no ephemeris was available, i.e. for dates in the distant past or future. A typical astrologer is quite interested in the distant past, when he calculates the nativities of illustrious people[62] or casts charts for the foundation dates of cities or kingdoms (dealing with the mundane astrology). An astrologer might also be interested in the future, e.g. while preparing so-called 'revolutions of the years'. Moreover, as a professional, an astrologer is expected to take care of his tool. As an actively practicing astrologer, he would not miss those misprints and would not hesitate to fix them once discovered.[63]

We have already seen that misprints can be useful for history (see fn. 17 above). The *Alfonsine Tables* purchased by Copernicus also contain several misprints, and some of them have been corrected by Copernicus. Unsurprisingly, these tiny corrections have barely been studied by historians so far, despite some suggestions that they might prove interesting.[64]

6.1. Research hypothesis

Of the 37 misprints in total, Copernicus corrected 7. *Prima facie*, this does not look like a substantial percentage. If Copernicus were a professional astrologer, one would expect a higher percentage of corrections. However, to avoid hasty conclusions, some other extant volumes of the same edition of the *Alfonsine Tables* were checked. Seventeen volumes have been studied.[65]

[61] The astronomical purpose of the annotations has been uncovered by many historians, with L.A. Birkenmajer (1900, pp. 26, 69) standing out among them. The suggestion of Maximilian Curtze (1875, pp. 27, 37) that the table in folio 113^{v} might serve an astrological purpose is groundless.

[62] E.g. BnF, lat. 7395 contains nativities of Jesus Christ, Prophet Muhammed, Emperors Frederick III and Maximilian, Louis XI of France, etc.—likely calculated with the tables owing to the unavailability of an ephemeris.

[63] Unfortunately, we could not source the *Alfonsine Tables* which with certainty belonged to a professional astrologer. However, we did study a handwritten almanac which used to belong to S. Belle—a professional French astrologer (see Averal de Carvalho 2018). Since it is a manuscript, it has scribal errors on almost every page, and most of them have been carefully corrected.

[64] E.g. Stefan Kirschner and Andreas Kühne wrote the following in CGAV (on pp. 585–586): 'In diesen Tabellen nahm Copernicus einige Korrekturen vor, die in den meisten Fällen nur Druckfehler berichtigen. Sie sind nur insofern interessant, als sie Auskunft darüber geben, wie sorgfältig Copernicus das ganze Werk studiert hat'.

[65] These are digitised copies which can be traced via: https://gesamtkatalogderwiegendrucke.de/docs/ALFOWEI.htm (for GW 01258).

The misprints were not corrected at all in most of them, 1 or 2 errors in the titles were corrected in some of them, and only in a single copy (INC. 811 in BNP, http://purl.pt/32066h as many as 18 misprints were corrected. Unfortunately, reliable information on the owner is lacking. It would be circular reasoning to use the high number of corrections as a basis for the claim that a volume belonged to a professional astrologer while the other copies were purchased by amateurs or bibliophiles.

Let us look at the misprints and their corrections more carefully. Of the 37 misprints in total, only 24 (or 22 by group count[66]) are pertinent to the data (the rest are misprints in the headers and other inscriptions). Copernicus primarily paid attention to these misprints. He corrected just a single misprint in the titles, the most apparent one,[67] while he discovered and corrected 6 errors (or 4 by group count) in the data. The full list of the misprints in the data is provided in Appendix 1. Twenty of them can be further categorized as easily discernible. The easily discernible misprints involve a number in an ordered sequence, which stands out from the rest, and this is why it is immediately obvious. The misprints that are more difficult to find require sexagesimal calculations to be discovered:

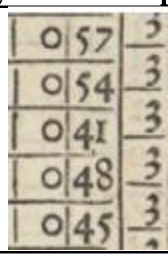
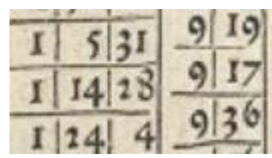
Easy-to-find misprint	**Difficult-to-find misprint**
	
41 stands out from the ordered sequence of numbers. The column of differences on the right shows that there should be a 3-unit difference between all the numbers. This confirms the guess—the correct number should be 51, not 41.	No numbers stand out from the main ordered sequence (in the 3rd column, the differences column is of auxiliary importance only). Only a very attentive reader would discover that 1;5;31 + 9;17 is not 1;14;28 but 1;14;48 and then proceed to surmise that the differences column also contains a mistake—9;36 should have been 9;16.

Figure 11. Easy- and difficult-to-find misprints in the *Alfonsine Tables*.

Hence, it is no wonder that Copernicus corrected no misprints that were difficult to find.[68] Let us generalize from that fact and ask ourselves how Copernicus could have discovered those misprints. The *Alfonsine Tables* were not a literary work; nobody was going to study the long columns of numbers sequentially. Therefore, Copernicus surely discovered the misprints when he calculated some planetary positions. These calculations could have been performed both for astrological and astronomical purposes. In the latter case, a plausible guess is that Copernicus employed the *Alfonsine Tables* to check the validity of the ancient observations he used to develop his theory. As a conscientious scholar under the circumstances of the 16th century, he could not

[66] Sometimes 2 or more numbers in a sequence are wrong. They would naturally be discovered and corrected as a group. The misprints 11, 12, and 13 as well as 20 and 21 form such groups.

[67] See https://derebus.nl/ca.aspx?id=1319.

[68] Another plausible reason is that all the rows containing those difficult-to-find misprints are found on the *Motus accessus et recessus sphaere stellare* page (i.e. precession) and correspond to the years A.D. 171–1202. These years were presumably of little or no use to Copernicus.

just blindly trust the information at hand, even in printed volumes,[69] and—lo and behold—the ancient observations which Copernicus listed in *De Revolutionibus* do make a perfect 'fit' with the misprints he corrected, as will be demonstrated below.

6.2. Invocations of the *Alfonsine Tables*

The *Alfonsine Tables* were of several different kinds. However, the ones relevant for our purposes, *viz.* those containing the misprints in data, either facilitated calculations of a medium motion of the planets or contained so-called equations, which enabled the computation of their true positions.

- The former kind (there is just one such table in our list; number 22) served as a sexagesimal multiplication table for a constant representing the average daily movement of a planet—in this case, Saturn. First, the scholar was supposed to calculate the time elapsed from a certain epoch (*radix*) to his or her intended date, then use the table to determine the average distance the planet had moved from the known radix position. Unfortunately, the row which the scholar would refer to in such a way does depend on the chosen radix. Consequently, we cannot use the misprint 22 to assess the correlation with Copernicus's observations in *De Revolutionibus*.
- However, the tables of the latter kind (all the records in our tables apart from 22) are perfectly suitable for the task at hand, since they are radix-invariant.[70] Such a table usually contains the equations for 60 entries (except for the Sun), called arguments (30 records for the primary arguments and 30 records for their complements to 360 degrees). Hence, there are 6 tables per planet. During the calculations, the scholar invokes the tables with 3 different arguments for all the planets except the Moon, for which 2 invocations suffice.[71] Each invocation normally involves checking the two neighboring rows, since the scholar must interpolate between two values. Thus, the arguments, i.e. ultimately the date, determine the exact places in the tables which the scholar would refer to (hit) during the calculations, and we can assume there are 90[72] such places per planet in total.

Therefore, the following assumptions are very plausible:

[69] The calculations per the *Alfonsine Tables* are sufficiently accurate (they are within, at most, several degrees from the reported observations) to exclude the possibility of gross misprints. Checking the accuracy of the *Alfonsine Tables* might have constituted another reason for Copernicus to perform the calculations.

[70] The equations depend on the geometrical position of the planets on the deferent-epicycle against the viewing point (the Earth), and they are ultimately the derivates of the date-time for which the positions are calculated. This is why they are radix-invariant.

[71] We are not interested in the Sun, since there are no misprints in its tables in Copernicus's volume. For the Moon there are 4 parameters to fetch from the tables – so-called C3 (*equatio centri*), C4 (*equatio argumenti*), C5 (*diversitas diametri*) and C6 (*minuta proportionalis*). C3 and C6 share one argument, C4 and C5 another one. For all the other planets (Mercury, Venus, Mars, Jupiter, Saturn) the 3 different arguments are for Et *equatio centri*) #1, C5 (*longitudo longior*), C6 (*equatio argumenti*), C7 (*longitudo propior*) #2, and C8 (*minuta proportionalis longiora*) #3. In the *Alfonsine Tables* the arguments of Et and C8 (so-called mean and true eccentric anomaly $\bar{k}$ and k_0 correspondingly) are geometrically related and due to a small eccentricity close (within a few degrees) to each other. See Neugebauer (1975, pp. 93ff, 183ff).

[72] 360 degrees results in 180 different rows since each row is dedicated to an argument and its complement. Since every invocation involves two neighboring rows, we further divide the number of different places by 2.

A1. The probability of finding a misprint on a page while referring to a different page is 0.

If the same page is referred to:

A2. The closer the misprint is to the hit, the higher the probability of its discovery. However, we should not presume that it ever reaches 1—*errare humanum est*.[73]

A3. The probability of finding a misprint increases when the hit is in the same column as the misprint.

A4. The probability of finding the misprint increases when the hit is below it in the table. Since the *Alfonsine Tables* contain no horizontal lines separating the records, it is natural to use a ruler, which would inevitably cover the records below the hit.

Assigning any numerical values to the probabilities mentioned above is only possible in an *ad hoc* fashion. Fortunately, we do not need that for our purposes. In summary, Copernicus (or, rather, the collection of the ancient observations he *ex hypothesi* had to check) had been both very 'unlucky' to avoid those misprints he did not find and very 'lucky' to land very close to the misprints which he did correct. Let us suppose that the dates, for which the planetary positions had to be calculated, were truly random. What would be the probability of being at least as 'unlucky' and 'lucky' as Copernicus provided the number of invocations were the same? Assigning a generous upper bound to that probability of 'coincidence' would suffice to quantify the required 'fit'.

6.3. Tracking Copernicus's path through the *Alfonsine Tables*

Let us now proceed to track Copernicus's presumed calculations. The software described in section 4.2 of the paper both greatly simplified the calculations and ensured that human error was avoided.

De Revolutionibus includes 37 ancient observations of planets, covering a period from 271 B.C. (Timocharis ca. 320–260 B.C.) to A.D. 882 (al-Battani ca. A.D. 853–929).[74] We can immediately disregard 5 of them which are dedicated to the Sun, since there are no misprints in its tables in Copernicus's volume. Let us first consider those planets for which Copernicus did not find the misprints. For these planets, to simplify matters and avoid overoptimistic conclusions, we will merely calculate the probability of hitting the wrong pages, since he would have certainly been unable to find the misprints in this case (assumption A1).

1. Venus. There are two misprints on two pages in Copernicus's volume for the tables dedicated to Venus (records 15–16 in Appendix 1), and they have not been corrected. There are 10 ancient observations of Venus in *De Revolutionibus*, and Copernicus had to make 30 invocations of the tables for them. However, 2 of the arguments (Et and C8, see fn. 71) cannot be considered independent random variables, since they are always close (within a few degrees) to each other. To be on the safe side and avoid overoptimistic conclusions, we will consider them a single invocation. Hence, the total number of invocations is 20. Only

[73] E.g. Copernicus, despite correcting the misprints 11 and 13, missed the misprint 12 located alongside them. On a single occasion, he even corrected a non-existent misprint—see https://derebus.nl/ca.aspx?id=1321.

[74] The rest of the observations are contemporary to Copernicus's time. He either did not need to check them or likely had an ephemeris which eliminated the need to use the *Alfonsine Tables*. Swerdlow and Neugebauer (1984, pp. 551ff) compiled the full list of the observations mentioned in *De Revolutionibus*.

4 of them are on the same page as the misprints (they are quite far from them, but we will generously not take that into consideration). The probability of missing 2 pages out of 6 is 2/3. Therefore, the probability of missing at least 16 times out of 20 is $p_{venus} \approx 0.1515$.[75]

2. Mars. There is one misprint in Copernicus's volume for the tables dedicated to Mars (record 17 in Appendix 1), and it has not been corrected by Copernicus. There are 3 ancient observations of Mars, so Copernicus must have made 6 different invocations of the tables (actually, 9 invocations, but for similar considerations as with Venus, we have reduced it to 6). None of them are on the same page as the misprints. The probability of missing 1 page out of 6 is 5/6. Therefore, the probability of missing 6 times out of 6 is $p_{mars} \approx 0.3349$.
3. Saturn. There are two misprints in Copernicus's volume for the tables dedicated to Saturn (records 23 and 24 in Appendix 1, since record 22 is dedicated to the medium motion), and they have not been corrected by Copernicus. There are 3 ancient observations of Saturn, so Copernicus must have made 6 different invocations of the tables (9 is reduced to 6 again). None of them are on the same page as the misprints. The probability of missing 2 pages out of 6 is 2/3. Therefore, the probability of missing 6 times out of 6 is $p_{saturn} \approx 0.08779$.

Since every observation is independent of the others, we can estimate the upper bound for the probability of being so 'unlucky' for the whole collection of 16 observations: $p_{unlucky} \leq p_{venus} * p_{mars} * p_{saturn} \approx 0.00445$.

Copernicus was lucky to correct some misprints for 3 other planets. Let us calculate the corresponding probabilities of landing at least as close to them in the tables as he presumably did:

1. The Moon. There is a single misprint in Copernicus's volume for the tables dedicated to the Moon (record 5 in Appendix 1), and it has been corrected. There are 6 ancient observations of the Moon in *De Revolutionibus*, so Copernicus must have made 12 different invocations of the tables. One of them is almost a direct hit: for the observation of Ptolemy from A.D. 01/10/135, Copernicus would have landed in the same table (see assumption A1), the same column (A3), just 3 rows away (A2), but higher in the table (A4).[76] The probability of such a hit is rather small.[77] However, to be on the safe side, it should be noted that annotations of astronomical nature have been made by Copernicus throughout this page, so we will estimate p_{moon} as 1 accordingly.
2. Mercury. There are 9 misprints[78] in Copernicus's volume for the tables dedicated to Mercury (records 6–14 in Appendix 1), and two of them have been corrected.[79] There are 7 ancient

[75] A binomial distribution model is presumed. The probability of hitting (in this case missing) the target p = 2/3. Therefore, the probability of hitting the target exactly k = 16 times in n = 20 trials is $p_{16} = \binom{n}{k}p^k(1-p)^{n-k} = \binom{20}{16}(\frac{2}{3})^{16}(\frac{1}{3})^4 \approx 0.091$. To obtain the probability of hitting 'at least 16 times', we must sum the corresponding probabilities $p_{>=16} = p_{16} + p_{17} + p_{18} + p_{19} + p_{20} \approx 0.091 + 0.0429 + 0.0143 + 0.0030 + 0.0003 \approx 0.1515$. The calculations of all the other probabilities mentioned below are available upon request.

[76] See https://derebus.nl/ca.aspx?id=1142.

[77] Exactly one hit ≈ 0.27549. At least one hit ≈ 0.33424.

[78] It is actually 7, since the misprints 9, 10, and 11 can be grouped, as they are adjacent, but we intend the upper bound to be as safely high as possible.

[79] It is actually 1, since the misprints 9 and 11 can be grouped, as they are adjacent.

observations of Mercurius in *De Revolutionibus*, so Copernicus must have made 14 different invocations of the tables (21 is reduced to 14). Three (!) of them are direct hits: for the observations of Ptolemy from 05/04/135, 05/07/139, and 02/02/141, Copernicus would have landed in the same table (A1), the same column (A3), and the same (!) row (A2, A4). The probability of such a coincidence is negligible ($p_{mercury} \approx 0.0004555$).[80]

3. Jupiter. There are 4 misprints[81] in Copernicus's volume for the tables dedicated to Jupiter (records 19–21 in Appendix 1), and two of them have been corrected.[82] There are 3 ancient observations of Jupiter in *De Revolutionibus*, so Copernicus must have made 6 different invocations of the tables (9 is reduced to 6). One of them is a hit: for the observation of Ptolemy from 08/10/137, Copernicus would have landed in the same table (A1), 6 rows away (A2), below in the table (A4), but not in the same column (A3). The probability of such a coincidence is $p_{jupiter} \approx 0.33897$.[83]

Since each observation is independent of the others, we can estimate the upper bound for the probability of being so 'lucky' for the whole collection of 16 observations: $p_{lucky} \leq p_{moon} * p_{mercury} * p_{jupiter} \approx 0.00001$. The total probability of coincidence on similar grounds can be finally estimated as $p_{coincidence} \leq p_{lucky} * p_{unlucky} \approx 6.88 * 10^{-7}$—it is vanishingly small.

Despite having quantified the probability of coincidence, we cannot claim that it is definite proof of Copernicus using the *Alfonsine Tables* exclusively for astronomical purposes. However, the odds are very high that the perfect match is not a coincidence. So far, we have attributed Copernicus's corrections or lack thereof to him being 'lucky' or 'unlucky', but in reality, they are surely a necessary consequence of his astronomical interests. Let us consider the 3 nearly magical 'direct hits' of the Mercurius observations mentioned above. These 3 observations are not random at all; they are carefully chosen so that the elongation of Mercurius from the Sun would be at its maximum (see Swerdlow and Neugebauer 1984, pp. 416–418). The rows of the *Alfonsine Tables* on folio 76^{v} with arguments 111–112 and 248–249 (records 9–11 in Appendix 1) correspond exactly to this planetary position (c6 = 22;02, see Neugebauer 1975, table on p. 285, fig. 184 on p. 1263, and fig. 188 on p. 1265). Therefore, it is no wonder that Copernicus landed in the *Alfonsine Tables* at this exact place. The 'luck' of correcting this particular misprint is due solely to its presence there and not somewhere else in his printed volume.

However, this is patently not the case for an alternative hypothesis of astrological use, since the dates in that case would not be chosen by the astronomical positions of the planets. This would produce truly random invocations of the *Alfonsine Tables*. To cast just 6 astrological charts for dates in the distant past or future, Copernicus would have had to invoke the *Alfonsine Tables* more often than would be required for the 32 ancient observations in *De Revolutionibus*. He would consequently be able to find and correct more misprints. E.g. for the misprints of Venus, Mars, and Saturn, the probability of hitting at least one of them (the same table at a distance of 6 rows, under the misprint, arbitrary column, i.e. exactly the same conditions as the misprints for Jupiter

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[80] At least 3 hits. Exactly 3 hits ≈ 0.0004416.

[81] It is actually 3, since the misprints 20 and 21 can be grouped, as they are adjacent, but we intend the upper bound to be as safely high as possible.

[82] It is actually 1, since the misprints 20 and 21 can be grouped, as they are adjacent.

[83] At least 1 hit. Exactly 1 hit ≈ 0.2833.

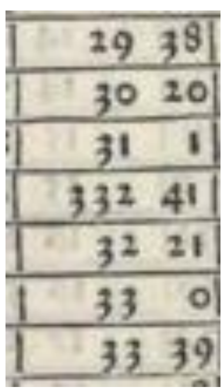
discovered by Copernicus) while calculating 6 charts for the randomly chosen dates is already about 0.986—a virtual certainty.

Since Copernicus kept his copy of the *Alfonsine Tables* until the end of his life, we can conclude that the study of the misprints does not corroborate the hypothesis that he was a professional astrologer or a devoted practitioner of astrology—this deals a severe blow to the positive answers of both **Q4** and **Q2**.

6.4. Misprints elsewhere

If Copernicus could have dispensed with the *Alfonsine Tables* to calculate planetary positions for recent dates, the other tables for calculating the cusps of astrological houses and, eventually, the so-called directions and profections would have been indispensable (their usage for astronomical purposes is limited). Astrology has many algorithms to calculate the houses, but the Regiomontanus system was by far the most popular in Copernicus's time, which can be testified by the extant private collections of nativities. This is why he purchased Regiomontanus's *Tabulae directionum et profectionum* and bound them into a single volume together with the *Alfonsine Tables* (currently Copernicana 4 in the Uppsala University Library). Considering Copernicus did not hesitate to correct the misprints in the *Alfonsine Tables* (even those which did not have a significant effect on the outcome of the calculation), we would expect him to do the same with *Regiomontanus Tables*. However, there is not a single correction found in the whole book (see CGAIV, pp. 591–595).

However, this book, predictably, also contains misprints. Moreover, some of them are located on pages which Copernicus should have used to calculate astrological charts—they correspond to the latitudes of Kraków, Toruń, and Frombork.[84] Furthermore, some of these are easily discernible:



29	38
30	20
31	1
332	41
32	21
33	0
33	39

Figure 12. Easily discernible misprint in *Regiomontanus Tables*[85]

The numbers 332 41 stand out from the ordered sequence of numbers—they should have been 331 41.

[84] We found 7 misprints with the naked eye on the pages for latitudes 50 (Kraków), 53 (Toruń), and 55 (Frombork).

[85] Folio 212^r, corresponding to the latitude of 50 degrees, *sc.* of Kraków, by 5 degrees Aquarius. See https://www.alvin-portal.org/alvin/view.jsf?pid=alvin-record:111080.

The absence of corrections to the misprints *per se* does not make this argument stronger than the argument from lack of evidence (see subsection 3.2.2). However, taken in combination with the previous discussion of the *Alfonsine Tables*, it is a game changer. We know that Copernicus did not hesitate to correct the misprints in the *Alfonsine Tables*. Therefore, it is quite natural to expect him to have done the same with *Regiomontanus Tables*. An astrologer casting a single chart must invoke the table of corresponding latitude several times. Accordingly, had Copernicus cast charts regularly, he would have landed close to the misprints and eventually would have corrected them. By disregarding the possibility of using a different exemplar of the tables or a different house system as highly unlikely,[86] we are led to an inevitable conclusion—Copernicus was not a practitioner of astrology, not even in his youth. This conclusion deals yet another severe blow to the positive answers of both **Q4** and **Q2**.

7. Conclusion

Let us integrate all the available arguments and propose the most plausible answers to the research questions posed in chapter 2:

Q1.‘Was Copernicus thoroughly educated in astrology? Did he possess expert knowledge of astrology? Did he possess the skills to apply its rules and algorithms?’ The answer to these questions is a qualified ‘Yes’. While the arguments presented in subsections 3.1.1 and 3.1.2 seem to be insufficiently persuasive to prove the point, subsections 3.1.3, 3.1.7, and 3.1.8 corroborate the positive replies. As a student, Copernicus certainly followed the Kraków university curriculum and acquired some knowledge and skills of astrology. Moreover, he seems to have had access to some extra-curricular astrological sources and applied his knowledge to practical problems, probably casting some charts (subsection 3.1.7). However, based on the evidence, we cannot claim that he became an expert in the field, retaining and applying the acquired knowledge until his mature years (see chapter 6).

Q2.‘Did Copernicus believe in astrology? Did he accept its assumptions and axioms as well as the logical inferences made from them?’ The answer to these questions is a qualified ‘No’. While all the arguments of section 3.1 seem to be inadequate to argue to the contrary, the reasoning of subsection 3.2.3 and the newly found evidence presented in chapters 5 and 6 corroborate the negative replies. A true devotee of astrology would definitely care to rectify his or her own nativity, cast charts of some important events in the distant past or future and use Regiomontanus’s tables to calculate the cusps of astrological houses. However, in all likelihood, Copernicus learned and did not question astrological assumptions in his youth (subsection 3.1.7). He might also have been dismissive of astrological speculations on historical figures or of mundane astrology and in this case, he would not have used the *Alfonsine Tables*. We should also stop short of claiming that the mature Copernicus believed that astrology was a pseudo-science, which would make him a modern scientist. He most likely simply bracketed these ideas and refrained from making any judgments because he did

[86] We consider it unlikely that Copernicus, already possessing a book, would make a copy of some frequently invoked pages or purchase different tables while he could easily use a few bookmarks, achieving the same purpose in an easier and cheaper manner.

not consider it important to resolve them. Copernicus generally preferred to remain silent on issues about which he was unsure (such as the physical constitution of the heavenly orbs or the infiniteness of the universe – see fn. 30).

Q3.'Did Copernicus practice astrology in his youth or student years?' The answer to this question is a qualified 'No'. While all the arguments of section 3 (with the exception of subsection 3.1.7) seem to be inadequate to argue *pro* or *contra*, the newly found evidence presented in chapters 5 and 6 corroborate the negative replies. A practicing astrologer would surely rectify his or her birth chart. We find no traces of astrological calculations in the *Alfonsine Tables* or *Regiomontanus Tables* Copernicus purchased in 1493. However, Copernicus most likely dabbled in astrology in his youth, as the argument in subsection 3.1.7 demonstrated.

Q4.'Did the mature Copernicus practice astrology?' The answer to this question is a qualified 'No' for essentially the same reasons as Q3. While all the arguments of chapter 3 seem to be inadequate to argue *pro* or *contra*, the newly found evidence presented in chapters 5 and 6 corroborate the negative replies. A practicing astrologer would surely rectify his or her birth chart while Copernicus seems to have preferred a number-symbolic solution. Surprisingly, we find no traces of astrological calculations in the *Alfonsine Tables* or *Regiomontanus Tables* which Copernicus kept his whole life. While we cannot exclude the possibility that Copernicus used an ephemeris or an almanac rather than the *Alfonsine Tables* to cast astrological charts for some contemporary events, e.g. those that were required for his medical practice (see subsection 3.1.4), using a different copy of *Regiomontanus Tables* seems highly unlikely.

In summary, Copernicus most likely followed the path of a typical scholar of his age up to a certain point in his life. Being surrounded by astrologically minded people, having studied astrological literature, and having listened to astrological lectures, he likely became well-educated in astrology and had no reasons to doubt the major beliefs of the art. We will never learn exactly what happened afterwards. It might have been the death of his mother, as suggested by L.A. Birkenmajer (1924, pp. 50ff), which was in sharp contrast with the astrological judgments of Haly and Ptolemy. Alternatively, it might have been Pico's vehement criticism of astrology, the importance of which has been stressed by Robert Westman (2011). It might also have been an insight leading to geokinetic cosmology, which he considered hardly compatible with some tenets of astrology, as suggested with the aforementioned 'black swan' argument (see subsection 3.2.3). In fact, it might have been anything. Regardless, it was probably a highly unexpected and emotionally charged experience. After this, Copernicus was no longer an astrologer.

8. Author contributions

George Borski: Conceptualization, Formal analysis, Programming, Investigation, Methodology, Project administration, Resources, Visualization, Writing—original draft, Writing—review & editing.

Ivan Kolkov: Data curation, Programming, Investigation, Writing—review & editing.

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A circuitous path led us to Doctor David Juste, who, by the whim of Fortune, was busy at the time with his own research in the same direction. Our investigation of Copernicus's nativity would be unthinkable without his assistance. His intervention also saved the paper from several inaccuracies. Although we arrived at the idea to investigate the misprints in the *Alfonsine Tables* ourselves, the synergy with the thinking of Professors Stefan Kirschner and Andreas Kühne which we discovered later deserves to be called remarkable. Finally, we would like to express our gratitude to Professor Michał Kokowski, whose invitation to the conference 'Copernicus and Astrology', as well as useful suggestions and constant encouragement helped bring this project to fruition.

Appendix 1. Misprints in the data of the *Alfonsine Tables* owned by Copernicus[87]

Misprint N	Page N	Page name	Column N	Argument[88] 1	Argument 2[89]	Corrected by Copernicus	Easily discernible
1	49r	Acc-Rec[90]	1	8	352	No	No
2	49r	Acc-Rec	1	17	343	No	No
3	49r	Acc-Rec	1	25	335	No	No
4	49r	Acc-Rec	2	61	299	No	No
5	68r	Moon	5	95	265	**Yes**	Yes
6	75v	Mercury	3	45	315	No	Yes
7	75v	Mercury	3	49	311	No	Yes
8	76v	Mercury	4	104	256	No	Yes
9	76v	Mercury	4	111	249	**Yes**	Yes
10	76v	Mercury	4	112	248	No	Yes
11	76v	Mercury	5	112	248	**Yes**	Yes
12	77v	Mercury	2	164	196	No	Yes
13	77v	Mercury	2	176	184	No	Yes
14	77v	Mercury	5	151	209	No	Yes
15	71r	Venus	6	22	338	No	Yes
16	73v	Venus	6	168	192	No	Yes
17	79v	Mars	5	53	307	No	Yes
18	83r	Jupiter	2	5	355	No	Yes
19	83v	Jupiter	2	37	323	No	Yes
20	85r	Jupiter	5	131	229	**Yes**	Yes
21	85r	Jupiter	5	132	228	**Yes**	Yes
22	86v	Saturn	2	48	N/A	**Yes**	Yes
23	88r	Saturn	4	113	247	No	Yes
24	88r	Saturn	5	101	259	No	Yes

[87] See https://www.alvin-portal.org/alvin/view.jsf?pid=alvin-record%3A111078.

[88] The tables were supposed to be invoked with the so-called argument, which was normally the left-most column. Accordingly, we preferred to use the argument, rather than a row number. *NB*: the header of the argument column contained a number of the full 60-degrees to be added to the argument number under the sign s̈. E.g. s̈ = 2 meant 120 degrees.

[89] Usually, the same row corresponded to a different argument, a complement of the first one to 360 degrees. It was normally placed in the second left-most column. It also represented a number of the full 60 degrees to be added to the argument (*vide supra*).

[90] *Motus accessus et recessus sphaere stellare*.

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