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Erasmus Reinhold on Copernicus and the "saving of appearances": A preliminary reassessment

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Abstract

This study offers a preliminary reassessment of Erasmus Reinhold's role in disseminating Copernican astronomy and his epistemological conception of astronomy's purpose. While confirming Reinhold as a highly technical astronomer deeply engaged with *De revolutionibus*, it challenges the view that he was indifferent to cosmological questions. Reinhold praised Copernicus not for heliocentrism itself, but for laying new foundations to revive astronomy, particularly geocentric astronomy. Inspired by Copernicus, he may have envisioned a proto-Tychonic system that rejected celestial spheres without compromising planetary harmony. Unlike Andreas Osiander's instrumentalist interpretation, Reinhold understood "saving the appearances" as the pursuit of uncovering the true law and harmony underlying planetary motions—a search for the real geometry of the cosmos. Though influenced by an epistemology that privileged mathematics, his concept of harmony was not purely mathematical, as it remained rooted in a geocentric worldview. This reassessment highlights the complexity of Reinhold's thought and stresses the importance of considering contemporary receptions of his work to better understand his legacy during a pivotal moment in early modern astronomy.

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Introduction

Within the circle of scholars gathered around Philip Melanchthon (1497–1560) in Wittenberg, Erasmus Reinhold (1511–1533) stands out as a leading astronomer.[1] His textbooks on astronomy—such as his commentaries on Peurbach's *Theoricae novae planetarum* (Wittenberg, 1542) and on the first book of Ptolemy's *Almagest* (Wittenberg, 1549)—circulated widely across Western Europe and were reprinted multiple times. Reinhold is also known for adapting data from Copernicus's *De revolutionibus* (Nuremberg, 1543) into a new set of astronomical tables, the *Prutenic Tables* (Tübingen, 1551). For his role in disseminating both Ptolemaic tradition and the newly published

Copernican astronomy, Reinhold can rightly be regarded as a crucial figure in the history of astronomy. A proper understanding of his work can indeed help elucidate one of the major intellectual and cultural shifts in human history: the transition from a geocentric to a heliocentric worldview.

Reinhold and his work have been the subject of recent thorough studies, yet much remains to be done to fully understand his thought, particularly his epistemological view.[2] In the past, his ideas and attitudes have been linked to historiographical categories such as "functionalism" or "instrumentalism"—that is, the notion that astronomical models are merely computational tools, not intended to describe physical reality.[3] These interpretations have been associated with key historical figures such as Andreas Osiander (1498–1552), and the so-called "Wittenberg interpretation" of Copernicus's *De revolutionibus*.[4] More recent scholarship, however, has emphasized that while historiographical categories and labels can serve as useful heuristics, they should not be employed uncritically.[5] In this light, it seems appropriate to reassess Reinhold's views, to determine whether certain nuances were lost when his thought was subsumed under these categories.

This study focuses particularly on Reinhold's view of Copernicus and his understanding of the scope of astronomy as the enterprise of "saving the appearances."[6] A comprehensive reassessment of Reinhold's intellectual legacy would require a more extensive treatment than is possible here—this remains a desideratum. Within the scope of this paper, however, I aim to provide a concise preliminary reassessment, showing that some passages in Reinhold's writings may benefit from more nuanced interpretations.

Here, the 'reassessment' of Reinhold's thought is not necessarily intended to challenge earlier interpretations. Rather, in the first section of this paper, I examine whether our understanding of his role in the dissemination of the Copernican theory can be strengthened by considering notes and reflections left by his contemporaries. It is only in the second section that I propose a new reading of Reinhold's conception of astronomy and its ultimate purpose, bringing his idea of law and harmony of planetary motion into focus.

Reinhold's praise of Copernicus in the *Prutenic Tables* (Tübingen, 1551)[7]

Reinhold's name is often mentioned alongside those of Philip Melanchthon and Nicolaus Copernicus. Melanchthon, also known as the *praeceptor Germaniae* for his leading role in reforming education during the Reformation, had been Reinhold's teacher at the University of Wittenberg. In 1536, he appointed Reinhold to the chair of "higher mathematics," i.e. astronomy. Melanchthon believed that knowledge of astronomy and astrology was essential for living a virtuous life—one that recognized the existence of God. With his powerful rhetoric, he aimed to inspire in young students a passion for studying the motions and influences of the stars.[8]

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Reinhold's published works largely reflect this educational vision; they were designed to support and encourage the study of astronomy. As Owen Gingerich and Robert S. Westman epitomized, Reinhold was "the most influential astronomical pedagogue of his generation."[9] His commentaries on Peurbach's *Theoricae novae planetarum* and on the first book of Ptolemy's *Almagest* enjoyed wide circulation and had a lasting impact.[10]

Yet not all of Reinhold's writings were intended for beginners. His *Prutenic Tables* were aimed at readers with advanced knowledge of astronomy.[11] These tables were not written for students but for experienced practitioners and scholars in the field. It is in this more technical body of work that Reinhold expresses his opinions about Copernicus's accomplishments.

As is widely recognized, the *Prutenic Tables* are based on Copernicus's *De revolutionibus*, which was printed in Nuremberg in 1543.[12] However, through the mediation of Georg Joachim Rheticus (1514–1574), Reinhold became acquainted with Copernicus's ideas even before the publication of *De revolutionibus*. Indeed, as early as 1542, he included an implicit reference to Copernicus as the restorer of astronomy in his edition of Peurbach's *Theoricae novae*.[13] Yet it is only in the *Prutenic Tables*, published in Tübingen in 1551, that we find Reinhold's explicit praise of Copernicus:

> All posterity will gratefully commemorate [*celebrabit*] the name of Copernicus, by whose labor and study the doctrine of celestial motions was again restored from its near collapse. Under the light kindled in him by a beneficent God, he found and explained much which from antiquity till now was either unknown or veiled in darkness.[14]

This passage is well known. It has been quoted by major scholars such as Pierre Duhem, Gingerich, Westman, and Michel-Pierre Lerner.[15] However, what they cited is actually the version inserted into the 1566 Basel edition of Copernicus's *De revolutionibus*.[16] In fact, the original sentence is closely tied to a preceding passage in which Reinhold praises Copernicus over Ptolemy on a specific issue—namely, the understanding of the four causes determining the variation of the tropical year:

> The apparent tropical year is always shorter than the sidereal year. First, because the uniform motion of precession always exceeds the correction that must sometimes be made to it due to the [first] anomaly. Second, because it is also variable in itself, owing to four causes which Nicolaus Copernicus was the first to discover and explain through his exceptional skill and diligence. These causes are: [1] the unequal precession of the equinoxes (or of the equinoctial points); [2] the anomaly of the Sun's motion in the zodiac; and finally, the variation both of [3] the eccentricity and of [4] the apogee [of the Sun]. Among these causes, Ptolemy knew only the anomaly, which he did not consider particularly significant. Because of this [*Quapropter*], all posterity will gratefully commemorate the name of Copernicus…[17]

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This is merely a paraphrase in geocentric terms of what Copernicus states at the end of *De rev*. III, 13:

> […] I find that there are altogether four causes of the apparent nonuniformity [of the tropic year]. The first is the nonuniformity in the precession of the equinoxes, which I have explained [III, 3]. The second is the inequality in the arcs of the ecliptic which the Sun is seen to traverse, a nearly annual inequality. This is also subject to a variation by the third cause, which I shall call the "second inequality." The last is the fourth, which shifts the higher and lower apsides of the Earth's center, as will be made clear below [III, 20]. Of all these [four causes], Ptolemy [*Syntaxis*, III, 4] knew only the second, which by itself could not have produced the annual nonuniformity, but does so, rather, when intermingled with the others.[18]

As the editors of the French critical edition of *De revolutionibus* have summarized, Copernicus here identifies four causes for the non-uniformity of the tropical year: 1) the irregularity of the precession motion; 2) the eccentricity of the Earth's orbit; 3) the supposed variations in this eccentricity; 4) the very slow motion of the apsides of the Earth's orbit.[19]

In the paraphrase quoted earlier, Reinhold translates the four causes into geocentric language (when needed), shifting from an Earth-moving to a Sun-moving perspective. It is clear that the following praise is intended to honor Copernicus the astronomer, not heliocentrism. This aligns with the view of Copernicus as "another Ptolemy" (*alter Ptolemaeus*), a title attributed to him by many in the so-called "Melanchthon circle," including Reinhold.[20] Melanchthon himself praised Copernicus's observations and treatment of the variation of the tropical year. After making new observations, he and Caspar Creuziger (1504–1548) began "to admire and love Copernicus."[21] Creuziger, well versed in Ptolemy's *Almagest*, recognized the need for new observations to replace the *Alphonsine Tables*.[22] It was in this context, closely tied to the creation of tables, that Copernicus began to be admired at Wittenberg.

Interestingly, Reinhold had already considered Copernicus's four causes in his commentary on *De revolutionibus*. Although he intended to publish this commentary, his untimely death prevented him from doing so.[23] Fortunately, the manuscript has survived.[24] It opens with a discussion of *De rev*. III, 13—that is, the same chapter whose passage on the four causes of the non-uniformity of the tropical year Reinhold paraphrased and translated into geocentric terms in the *Prutenic Tables*. In fact, he had already reinterpreted that passage in geocentric terms in the commentary:

> The revolving year, also called tropical, natural or temporal, varies due to 4 causes:
> 1. The unequal change of the equinoctial points,
> 2. the unequal motion of the Sun in the zodiac caused by eccentricity,
> 3. the change in [the Sun's] eccentricity,
> 4. the change in [the Sun's] apogee.[25]

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Reinhold's exposition of Copernicus is consistently presented from a geocentric point of view. I argue here that, in context, this constitutes more than a mere terminological variation. Reinhold was evidently attempting to invert Copernicus's heliocentric model into a geocentric framework, and this attempt was closely tied to the compilation of new tables.

In 1960, Aleksander Birkenmajer demonstrated that Reinhold's commentary on *De revolutionibus* includes clear passages where he refers to a model for planetary motions developed "according to our new hypotheses" (*Iuxta nostras hypotheses novas*). He further showed that this model was geocentric and identified a passage in which Reinhold attributes the planets' retrograde motions to the motion of the Sun. Together, these findings led him to conclude that the geo-heliocentric system later developed by Tycho Brahe was originally conceived by Reinhold.[26]

This account aligns with Christoph Rothmann's (1550-1600) attribution of a geo-heliocentric view to Reinhold. In his correspondence with Tycho Brahe, he was surprised by the latter's claim of primacy concerning the geo-heliocentric system, and he wrote:

> Regarding your new hypotheses, which you mention in Chapter 8, I do not fully agree with you. Indeed, when I was writing my *Elementa Astronomica*, I arranged the Moon and then the Sun around the Earth in the same way. However, I used two homocentric epicycles [*Homocentrepicyclepicycli*], where the center of the larger and primary epicycle of the Sun in turn served as the center for the other planets' homocentric double-epicycle. In this way, the center of the homocentrics [*centrum Homocentricorum*] of the other planets was always the same as the center of the larger epicycle of the Sun, and the motion of the Sun was carried around the homocentric of the Sun [*in Homocentrico Solis*]. But I was aware that this was not a new arrangement [*ratio*]. In fact, it was entirely according to Copernicus, nor, conversely, could I have transferred Copernicus's hypotheses in all respects to the motion of the Sun otherwise. I saw that both Rheticus and Reinhold understood this arrangement [*ratio*].[27]

Although I am uncertain about Rothmann's reference to Rheticus, his reference to Reinhold clearly concerns the *Prutenic Tables*. The full title of his *Elementa Astronomica*—which remained in manuscript form and is dated 1587, according to Christine Schofield—reads as follows: *Astronomy, in which the Ptolemaic hypotheses are corrected and supplemented by those of Copernicus, with particular emphasis on explaining and demonstrating the rationale* [*intellectus*] *and use of the* Prutenic Tables (*Astronomia, in qua hypotheses Ptolemaicae ex hypothesibus Copernici corriguntur et supplentur: et imprimis intellectus et usus tabularum Prutenicarum declaratur et demonstratur*).[28]

By focusing on the origins and primacy of the geo-heliocentric system, A. Birkenmajer did not consider that Reinhold's commentary on *De revolutionibus* is more than a detached, "neutral," and purely technical analysis of Copernicus's masterpiece.[29] It is a

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work crafted with a specific purpose in mind, one that goes beyond the objective exposition of Copernicus's heliocentric astronomy. As Reinhold himself states, his commentary on *De revolutionibus* was intended to provide the rationale for the *Prutenic Tables*:

> First of all, I compared Copernicus's observations with those of Ptolemy and others as best as I could. Except for bare observations [*nudas observationes*] and traces of demonstrations [*demonstrationum vestigia*], I took practically nothing from Copernicus. Instead, I composed anew the tables [*canones*] for both uniform motions and prosthaphaereses, as well as all the rest, in which, in some cases, I followed an entirely different rationale [*ratio*]—one that I judged to be most appropriate. Indeed, I have explained the cause and the rationale [*ratio*] of each composition [of tables] in the commentary I wrote on Copernicus's *De revolutionibus*.[30]

The Bayerische Staatsbibliothek in Munich holds a 1571 edition of the *Prutenic Tables* bearing several intriguing annotations.[31] Notably, the reference to Reinhold's commentary on *De revolutionibus* in the quoted passage is underlined, and a marginal note reads: "it [viz. Reinhold's commentary] is not extant" (*quae* [*commentaria*] *non extant*) (see Fig. 1).

– – – Figure 1 – – –

A few pages later, the annotator underlined the following sentence:

> […] the *Prutenic Tables*, which I compiled through the generous support of the illustrious Duke of Prussia, were the result of great effort and many years of labor. I carefully compared both ancient and modern observations—*I have explained elsewhere how*. From all this, it is now clear that the study of celestial motions is impossible without mathematics [*numerorum doctrina*] and its application [*exercitio*].[32]

The passage I have italicized ("I have explained elsewhere how") is accompanied by a marginal note: "In the commentary on Copernicus" (*in commentarijs in Copernicum*) (see Fig. 2).

– – – Figure 2 – – –

This indicates that, simply by reading the *Prutenic Tables*, the annotator understood the nature of Reinhold's unpublished commentary on *De revolutionibus*. He inferred that the commentary was likely devoted to explaining how Reinhold crafted the *Prutenic Tables*—specifically, according to which model and observations.

In this regard, the annotator clearly understood the significant intellectual debt Reinhold owed to Copernicus. On the front flyleaf, after quoting a passage from Cicero's

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De Senectute,[33] he writes the following passage, whose meaning is clear despite two words being difficult to decipher (see Fig. 3):

> Whoever [will want?] to study the *Prutenic Tables* [properly?] must connect them with Copernicus, for they were built upon these foundations.[34]

– – – Figure 3 – – –

Although I am not confident enough to identify the annotator, I am certain he was familiar with the Wittenberg milieu. First, on the same flyleaf, the lower-left corner bears an indication of where and when the annotations were possibly written: Wittenberg, May 15, 1582 (see Fig. 4).[35]

– – – Figure 4 – – –

Furthermore, at the end of the book, immediately after the errata edited by Michael Maestlin, he cites a Latin epigram which he attributes to *Philippos* ("Φίλιππος"), i.e. Melanchthon.[36] This epigram was most likely taken from Reinhold's prefatory letter in *Ephemerides duorum annorum* <15>*50 et* <15>*51*, where the annotator could also read Reinhold's forward to the "candid reader," in which the dependence of the *Prutenic Tables* on Copernicus's *De revolutionibus* is clearly expressed as follows:

> Do not be surprised that my numerical values for celestial motions often differ considerably from the commonly used in the *Alphonsine Tables*. As the evidence itself shows, [those tables] no longer correspond well with actual observations. Although I intend to explain the rationale [*ratio*] behind my computation at another time and to present its foundations [*fundamenta*]—many of which I have drawn from the most distinguished Nicolaus Copernicus, who in this field of celestial science was by no means inferior to Ptolemy—nevertheless, those skilled in these disciplines, upon observing the heavens more precisely, will find that my computation comes as close to the truth as possible.[37]

The annotator's use of "foundations" (*fundamenta*) in reference to Copernicus's astronomy closely mirrors Reinhold's own usage in the quoted passage.

These annotations certainly deserve a thorough examination, as they likely bear testimony to the reception of the *Prutenic Tables*, especially in relation to Copernicus. In the context of this paper, they show that a 16th-century reader of the *Prutenic Tables* could infer that Reinhold's commentary on *De revolutionibus* focused less on Copernicus's heliocentric model and more on using his observations and mathematical arrangements to build more precise tables.

What I have presented here are just a few but crucial pieces of evidence showing that some early readers, simply by studying the *Prutenic Tables*, may have recognized that Reinhold's praise of Copernicus carried a specific meaning: it honored Copernicus

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primarily because he made it possible to rebuild geocentric astronomy on new foundations. More specifically, the geometry and observation included in *De revolutionibus* made it possible to produce new tables without abandoning geocentrism; on the contrary, they prompted its renovation.

"To save the appearances" in Reinhold's preface to the *Theoricae novae planetarum* (Wittenberg, 1542)

As James Evans aptly noted, "the choice of the Earth or the Sun as center has no bearing on the construction of planetary tables."[38] This naturally raises a question: Why did Reinhold go to the trouble of translating Copernicus's heliocentric arrangements into geocentric ones, particularly in a work intended to explain the construction of the *Prutenic Tables*? The question is especially relevant in light of the common characterization of Reinhold as an astronomer "less interested in the cosmological big picture than in the technical details of Copernicus's astronomy."[39]

According to A. Birkenmajer and Gingerich—echoing a claim originally made by Duhem—Reinhold's approach to astronomy was indeed consistent with the perspective presented in the *Ad lectorem* preface that Andreas Osiander anonymously added to *De revolutionibus*.[40] In this preface, Osiander explains that new astronomical hypotheses, like Copernicus's heliocentrism, are developed solely for computational purposes. In other words, they are not intended to describe physical reality, as doing so would exceed the bounds of astronomy. Westman included this perspective in what he fittingly called the "Wittenberg interpretation": a thorough but "pragmatic" reading of Copernicus's *De revolutionibus* shared by Melanchthon, Reinhold, and others at Wittenberg (except Rheticus), characterized by "the conspicuous absence of urgency about the issue of cosmological choice."[41]

While it is clear that Reinhold's interpretation of Copernicus was shaped by ideas circulating in Wittenberg, it remains open to question whether his approach to astronomy truly aligned with that of Osiander. Moreover, although it is true in principle that astronomical tables are independent of cosmological commitments, this independence should be problematized to determine whether it holds for all historical actors and contexts. In this light, one may once again ask why Reinhold did not simply adopt Osiander's caveat, but instead choose to develop new (*novae*) geocentric "hypotheses."

One possible explanation is that Reinhold did not fully accept Osiander's view of astronomy as merely a computational science without cosmological implications. While that perspective might have been applied to Copernicus's heliocentric model, Reinhold seems not to have regarded it as a sufficient account of the scope of astronomy.

After all, within the Melanchthon circle, astronomy was considered a vital discipline for learning to philosophize properly.[42] It is likely no coincidence that, in the imperial privilege (*Diploma Caesareum*) authorizing him to publish the tables and appended to the beginning of the *Prutenic Tables*, Reinhold is referred to as a "professor of philosophy" (*Philosophiae magister*).[43] And just a few pages later, in the preface to the

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Logistice scrupulorum astronomicorum, Reinhold himself divides astronomy into two parts—distinguishing between theory (mathematical hypotheses) and practice (observations through instruments)—and states that both are governed by geometry. In doing so, he explicitly refers to astronomy as a form of "philosophy" (*Geometria utranque huius Philosophiae partem potissimum gubernat*).[44] Pierre Duhem, however, substituted "philosophy" with "astronomy" in his translation, using the passage to support his portrayal of Reinhold as advocating a 'functionalist' view of astronomy—much like Proclus, Osiander, and Gemma Frisius.[45]

At any rate, it is undeniable that a subtle yet significant shift in the status of both philosophy and astronomy can be traced to Wittenberg, where increasing emphasis was placed on the foundational role of mathematics. This development is especially evident in educational texts aimed at younger students, where Reinhold closely follows Melanchthon's ideas and rhetorical style.[46] Drawing loosely on Plato, Melanchthon described geometry and arithmetic as the two wings of the soul, enabling the human mind to grasp the divine structure of the cosmos.[47] Reinhold adopts this evocative metaphor in the prefatory letter to Christoph von Carlowitz, which accompanies his edition of the first book of the *Almagest*, first published in 1549.[48] In another prefatory letter appended to his commentary on Peurbach's *Theoricae novae planetarum*, first published in 1542, he likewise stresses that anyone aspiring to true philosophy must study Ptolemy directly.[49] The *Almagest* was thus considered both an astronomical and a philosophical work.

In this context, one might expect the well-known phrase "to save the appearances" to assume a distinct meaning. Traditionally, it refers to the primary aim of astronomy: to account for the apparent irregularities in planetary motion through mathematical models, which enable the accurate prediction of celestial positions without necessarily reflecting the true structure of the cosmos.[50] For Reinhold, by contrast, the phrase still relates to astronomy's fundamental goal; however, that goal itself is redefined. He sees astronomy not merely as a predictive tool, but as a discipline that uncovers the law and harmony underlying planetary irregularities or anomalies. In this light, appearances are "saved" not by abstract modeling alone, but by aligning them with a real, intelligible cosmic order.

In the preface to his commentary on Peurbach's *Theoricae novae planetarum*, Reinhold refers to the "harmony of irregularity" (*harmonia irregularitatis*), arguing that while celestial spheres (*coelestes orbes*) may not exist in reality, they are nonetheless necessary for helping the limited intellects of human beings grasp the divine law and harmony governing planetary motions, including their anomalies:

> Hence the great number of celestial spheres brought together in this way must be pardoned because of art or rather because of the weakness of our intellect. For even if these seven beautiful and shining bodies possess a divine indwelling power, that one by one preserves the law of its motion and eternal harmony in diversity or irregularity without these kinds of spheres, for us, however, without all these many spheres, it will at least be extremely difficult to rationally comprehend this, as I might say, harmony of irregularity, or to pursue it in thought.[51]

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This argument comes at the end of a rather long passage explaining the objective of Peurbach's *Theoricae*, namely, "saving the appearances" (*si quis omnino velit copiosus huius libelli scopum explicari, is sciat in summa illud hic agi, ut coelestium motuum ac corporum nempe planetarum apparentiae salventur*), and it has been interpreted in various ways.

Contrary to Duhem's reading, recent interpretations have rightly emphasized that its meaning goes beyond a simple instrumentalist/realist divide.[52] However, in my view, it has not yet been sufficiently emphasized that Reinhold presents astronomy as a science that uncovers the *true* law and *real* harmony governing planetary motions. He does not believe it impossible to comprehend the "harmony of irregularity" without celestial spheres, but sees them as essential aids for rational understanding. In the context of teaching Peurbach's *Theoricae novae planetarum*, the spheres were indeed a useful pedagogical tool for grasping the mathematical model behind each planet's motion.[53]

Still, it is noteworthy that Reinhold bypasses the question of whether the celestial spheres are real entities, instead pointing directly to what he sees as truly at stake in astronomy—namely, the law or harmony of planetary motions. He is also convinced that physics and natural philosophy cannot contribute to uncovering this cosmic harmony, as that task belongs to astronomy, which he regards as the branch of philosophy governed by mathematics. According to Reinhold—leaning on Plato—mixing physical considerations with geometric results is not only meaningless but also detrimental.[54] This, of course, stands in contrast to the subsequent development of astronomy, as later exemplified by figures such as Johannes Kepler and Galileo Galilei, who, in different ways, went beyond the traditional role of the astronomer and entered the realm of natural philosophy.[55] However, this also clearly demonstrates how misleading it is to characterize, in Barker's and Goldstein's words, sixteenth-century astronomers as "perpetually frustrated realists."[56] The account offered by Barker and Goldstein remains framed within the so-called "split" interpretation, which calls for careful reconsideration, since the very categories it employs—realism and instrumentalism—prevent us from recognizing distinctive positions such as Reinhold's, in which the reality of an astronomical model does not depend on causal explanations grounded in natural philosophy.

Reinhold's uncommitted attitude toward the existence of celestial spheres should be seen as an original and nuanced position, one that does not fully align with that of Melanchthon and Paul Eber. In the *Initia doctrinae physicae* (Wittenberg, 1549), they explicitly advocated for the real existence of celestial spheres.[57] Reinhold, by contrast, treated their existence as a problem unworthy of the attention of an astronomer concerned with "saving the appearances"—that is, with uncovering the harmony of planetary motions.[58] And if his earlier-mentioned "new hypotheses" truly resembled a geo-heliocentric Tychonic model, then one may reasonably suppose that he eventually discarded the idea of solid celestial spheres.

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Concluding remarks

This preliminary reassessment confirms earlier portrayals of Reinhold as a mathematical astronomer deeply engaged with the most technical aspects of *De revolutionibus*, while largely disregarding Copernicus's heliocentric cosmology. However, in contrast to those same accounts, it also reveals that Reinhold's technical engagement should not be interpreted as definitive evidence of his lack of commitment to cosmological questions. In fact, his conception of astronomy's purpose differs notably from that of Osiander. For Reinhold, "saving the appearances" is not merely about identifying the most effective mathematical model for calculating planetary motions. Rather, it is—above all—about uncovering the true law and harmony underlying the planets' seemingly irregular motion. It is about discovering the real geometry of the world.

This perspective appears to have remained intact during the construction of the *Prutenic Tables*. Reinhold regarded Copernicus as a major astronomer worthy of the highest praise—not because of his heliocentrism, but because his work paved the way for revitalizing geocentric astronomy on revised and more robust foundations. He likely believed it was possible to invert Copernicus's heliocentric model into a geocentric one. Hypothetically, this would have resulted in what we may call today a 'proto-Tychonic' system, incompatible with the existence of solid celestial spheres. However, for Reinhold, abandoning the celestial spheres would not have been a significant loss. Unlike his mentor Melanchthon, he maintained a stance of agnosticism regarding their existence. He was most likely convinced that the inquiry into the true law and harmony of planetary motion need not depend on specific physical assumptions, such as the existence of celestial spheres.

However, some form of physical, theological, or possibly astrological constraint appears to have prevented Reinhold from fully embracing Copernicus's heliocentrism. Although his view of astronomy was somewhat influenced by a Platonic-like epistemology—where mathematics alone suffices to understand the true order of the world as aligned with the appearances—his concept of harmony was not purely mathematical, as it remained firmly rooted in a geocentric cosmology. For this reason as well, I believe it is important to reassess the characterization of Reinhold as merely a technical astronomer unaffected by cosmological arguments. At the same time, this reassessment should also take into account how his contemporaries received his work, as this can offer a clearer and more nuanced perspective on Reinhold and his legacy.

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Notes on contributor

Ivan Malara is a postdoctoral fellow at the University of Milan, Italy. His current research focuses on Galileo Galilei's reception of Ptolemy and reflects a broader interest in the early Latin editions of the *Almagest*, for which he has begun compiling a census. He is the author of *Galileo and the* Almagest *(c. 1589–1592): How Ptolemaic Astronomy Influenced Galileo's Early Writings on Motion* (Cham, 2024).

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NOTES

[1] For recent accounts of Reinhold's life and work, see: O. Gingerich, "Reinhold, Erasmus," in C. Coulston Gilliespie (ed.), *Dictionary of Scientific Biography* (New York, NY: Scribner, 1975), vol. XI, pp. 365–7; A. Kühne, "Reinhold, Erasmus," in H.G. Hockerts (ed.), *Neue Deutsche Biographie* (Berlin: Duncker & Humblot, 2003), vol. XXI, cols. 367b–368a; J. Hamel, "Reinhold, Erasmus," in T. Hockey *et al*. (eds.), *The Biographical Encyclopedia of Astronomers* (New York, NY: Springer, 2007), pp. 962–3; and the "MacTutor Index" entry on Reinhold, available at: https://mathshistory.st-andrews.ac.uk/Biographies/Reinhold/ (accessed 20 June 2025).

[2] See P.D. Omodeo and I. Tupikova, "The post-Copernican reception of Ptolemy: Erasmus Reinhold's commented edition of the *Almagest*, Book One (Wittenberg, 1549)," *Journal for the History of Astronomy*, 44 (2013), 235–56; *Iid*., "Visual and verbal commentaries in Renaissance astronomy: Erasmus Reinhold's treatment of classical sources on astronomy," *Philological Encounters*, 3 (2018), 359–98.

[3] See P. Duhem, *To save the phenomena. An essay on the idea of physical theory from Plato to Galileo*, trans. E. Dolan and C. Maschler (Chiacago and London: Chicago University Press, 1969) [original title: *Sauver les apparences Σώζειν τα φαινόμενα. Essai sur la notion de théorie physique de Platon à Galilée* (Paris, 1908)].

[4] See A. Birkenmajer, "Le commentaire inédit d'Erasme Reinhold sur le 'De revolutionibus' de Nicolas Copernic," in *La science au seizième siècle* (Paris: Hermann, 1960), pp. 171–7; O. Gingerich, "Erasmus Reinhold and the dissemination of Copernican Theory," in O. Gingerich (ed.), *The Eye of Heaven: Ptolemy, Copernicus, Kepler* (New York, NY: American Institute of Physics, 1993), pp. 221–51 [originally published as "The role of Erasmus Reinhold and the *Prutenic Tables* in the dissemination of Copernican theory," in J. Dobrzycki (ed.), *Études sur l'audience de la théorie héliocentrique. Conférences du Symposium de l'UIHPS (Toruń 1973)*, *Studia Copernicana* VI (Wroclaw: Ossolineum, 1973), pp. 43–63, 123–5]; R.S. Westman, "The Melanchthon circle, Rheticus and the Wittenberg interpretation of the Copernican theory," *Isis*, 66 (1975), 163–93. These studies have decisively challenged earlier interpretations that characterized Reinhold as a Copernican; see, for instance, J.-B. Delambre, *Histoire de l'astronomie moderne* (New York and London: Johnson Reprint Corporation, 1969 [a facsimile of the Paris 1821 edition]), 2 vols., vol. I, p. 145.

[5] For a detailed overview of the issue, see G. Freudenthal, "'Instrumentalism' and 'realism' as categories in the history of astronomy: Duhem vs. Popper, Maimonides vs. Gersonides," *Centaurus*, 45 (2003), 227–48.

[6] The meaning of this well-known phrase will be clarified below.

[7] This section would have greatly benefited from an examination of Reinhold's annotated copy of *De revolutionibus*, held in the Crawford Library of the Real Observatory of Edinburgh; see O. Gingerich, *An annotated Census of Copernicus'* De revolutionibus *(Nuremberg, 1543 and Basel, 1566)* (Leiden-Boston: Brill, 2002), pp. 268–78. It is regrettable that a digital scan of this crucial volume is still unavailable. Equally concerning is that the library in possession of the material lacks the necessary facilities to produce, upon request, digital scans—or even simple photographs—for scholarly purposes. This represents a significant impediment to researchers who are unable to conduct their investigations on site, whether due to physical limitations or financial constraints.

[8] For Melanchthon's view on astronomy and astrology, see: S. Caroti, "Melanchthon's astrology," in P. Zambelli (ed.), '*Astrologi hallucinati'. Stars and the End of the World in Luther's Time* (Berlin and New York, NY: de Gruyter, 1986), pp. 109–21; I. Pantin, "La lettre de Melanchthon à Simon Grynaeus: Avatars d'une défense de l'astrologie," in *Divination et controverse religieuse en France au XVIe siècle* (Paris: Centre nationale des lettres, 1987), pp. 85–101; S. Kusukawa, "*Aspectio divinorum operum*. Melanchthon and astrology for Lutheran medics," in O.P. Grell and A. Cunningham (eds.), *Medicine and the Reformation* (London: Routledge, 1993), pp. 33–56; *Id.*, *The transformation of natural philosophy: The case of Philip Melanchthon* (Cambridge: Cambridge University Press, 1995), pp. 134–144; C. Methuen, "The role of the heavens in the thought of Philip Melanchthon," *Journal of the History of Ideas*, 57 (1996), 385–403; B. Bauer, "Naturphilosophie, Astronomie, Astrologie," in *Melanchthon und die Marburger Professoren (1527-1627)* (Marburg: Universitätsbibliothek, 1999), 2 vols., vol. I, pp. 345–439; C. Brosseder, "The writing in the

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Wittenberg sky: Astrology in sixteenth-century Germany," *Journal of the History of Ideas*, 66 (2005), 557–76; P.D. Omodeo, *Copernicus in the cultural debates of the Renaissance. Reception, legacy, transformation* (Leiden and Boston: Brill, 2014), pp. 87–92.

[9] O. Gingerich and R.S. Westman, "The Wittich connection: Conflict and priority in late sixteenth-century cosmology," *Transactions of the American Philosophical Society*, 78 (1988), i–viii+1–148, p. 27.

[10] See P.D. Omodeo and I. Tupikova, "Visual and verbal commentaries in Renaissance astronomy" (Note 2), pp. 390–2.

[11] *Prutenicae tabulae coelestium motuum autore Erasmo Reinholdo Salvedensi* (Tubingae: per Ulricum Morhardum, 1551), prefatory letter, s. α3: "… hoc opus non editur tyronibus…" (this work is not published for novices).

[12] See Gingerich, *op. cit*. (Note 4).

[13] *Theoricae novae planetarum Georgii Purbacchii Germani ab Erasmo Reinholdo Salvendensi pluribus figuris auctae, et illustrate scholijs, quibus studiosi praeparentur, ac invitentur ad lectionem ipsius Ptolemaei* (Vitebergae: per Ioannem Lufft, 1542), *Praefatio in Theorica*: "Tametsi video quendam recentiorem praestantissimum artificem, qui magnam de se apud omnes concitavit expectationem restituendae Astronomiae…" (I know of an exceptionally skillful modern astronomer who has aroused widespread anticipation for the restoration of astronomy); and in the commentary on the eighth sphere, s. ciij: "Itaque cum hae artes iam diu desiderent aliquem Ptolemaeum, qui labentes disciplinas restituat, ac in viam revocet, spero eum nobis tandem ex Prussia obtigisse, cuius divinum ingenium tota posteritas non immerito admirabitur" (Therefore, since these sciences have for a long time been longing for another Ptolemy—someone to restore the falling disciplines and set them again on the right path—I hope that at last we have found such a man from Prussia, whose divine talent, truly, all future generations will admire, and not without reason). For my English translation, I have taken into account those provided in Duhem, *op. cit*. (Note 3), p. 72.

[14] *Prutenicae tabulae* (Note 11), *Logisticae scrupulorum astronomicum*, precept XXI, f. 35r: "[T]ota posteritas grato animo Copernici nomen celebrabit, cuius labore et studio doctrina ipsa coelestium motuum propemodum collapsa iterum restituta est, et magna eius quoque lux Dei beneficio accensa inventis et patefactis ab eo multis, quae ad hanc usque aetatem vel ignota fuerant, vel obscura." My English translation is modeled on the one provided in Gingerich, *op. cit*. (Note 4), p. 221.

[15] See Duhem, *op. cit*. (Note 3), pp. 72–73; Gingerich, *op. cit*. (Note 4), p. 221; Westman, *op. cit*. (Note 4), p. 177; M.-P. Lerner, "Aux origines de la polémique anticopernicienne (II)," *Revue des sciences philosophiques et théologiques*, 90 (2006), 409–52, p. 445. A somewhat more precise contextualization of the passage is provided in Westman, *The Copernican Question. Prognostication, Skepticism, and Celestial Order* (Oakland: University of California Press, 2011), p. 152 col. a.

[16] Cf. N. Copernicus, *Gesamtausgabe* II: *De revolutionibus orbium coelestium: Textkritische Ausgabe* (Munich: Oldenbourg, 1949), p. 414, lines 16-21.

[17] *Prutenicae tabulae* (Note 11), *Logisticae scrupulorum astronomicum*, precept XXI, ff. 34v-35r: "Est autem hic Tropicus annus adparens semper tum minor anno sidereo, propterea quod aequalis motus praecessionis semper excedit id, quod interdum ratione anomaliae ab eo auferendum est, tum sui dissimilis propter quatuor causas, quas primus Nicolaus Copernicus dexteritate et solertia sua tandem depraehensas enunciavit. Hae sunt, inaequalis praecessio aequinoctiorum, vel sectionum aequinoctialum, Anomalia motus Solis in zodiaco, mutatio denique tum Eccentrotetis, tum apogei, e quibus causis sola anomalia, per se non magni momenti, cognita fuit Ptolemaeo. Quapropter tota posteritas grato animo Copernici nomen celebrabit…" Notably, Delambre pinpointed only three causes in his paraphrase of this passage; see Delambre, *op. cit.* (Note 4), p. 143.

[18] Copernicus, *Gesamtausgabe* II (Note 16), p. 176, lines 10-18: "Veruntamen ut ad resolutionem huius nodi aliquando veniamus, quatuor omnino causas invenimus inaequalis apparentiae. Prima est inaequalitas praeventionis aequinoctiorum quam exposuimus. Altera est qua Sol signiferi circumferentias inaequales intercipere videtur, quae fere anniversaria est. Tertia, quae etiam hanc variat, quamque secundam diversitatem

vocabimus. Quarta superest, quae mutat absides centri terrae summam et infimam, ut inferius apparebit. Ex his omnibus secunda solummodo nota Ptolemaeo, quae sola non potuisset inaequalitatem annalem producere, sed caeteris implicata magis id facit." English translation (including references) by E. Rosen, in J. Dobrzycki (ed.), *Nicholas Copernicus on the Revolutions*, vol. II (London: Macmillan, 1978), p. 146, lines 28-37.

[19] See N. Copernic, *De revolutionibus orbium coelestium*/*Des révolutions des orbes célestes*, édition critique, traduction et notes par M.-P. Lerner, A.-Ph. Segonds et J.-P. Verdet, 3 vols. (Paris: Les Belles Lettres, 2015), vol. III, p. 280, n. 23.

[20] See *supra*, note 13. On the *topos* of Copernicus as another Ptolemy, see Lerner, *op. cit*. (Note 15), pp. 446–7. The expression 'Melanchthon circle' was coined by Linn Thorndike in *A history of magic and experimental science*, vol. V (New York, NY: Columbia University Press, 1941), pp. 378–405.

[21] *Corpus reformatorum: Philippi Melanthonis opera quae supersunt omnia*, ed. C.B. Bretschneider and H.E. Bindseil, 28 vols. (Halle: 1834-1852; Brunswick: 1853-1860), vol. XI, *Oratio de Casparo Crucigero*, col. 839: "His et similibus observationibus moti, Copernicus magis admirari et amare coepimus. Eumque secuti, nostras observationes cum omnibus praecedentibus in hoc genere contulimus." Partially cited in M.-P. Lerner, *op. cit*. (Note 15), p. 442, n. 128. Interestingly, the *Oratio* was read by Reinhold (*ab Erasmo Reinholt recitata*).

[22] Cf. *Corpus reformatorum* (Note 21), vol. XI, col. 838: "Iamque in μεγάλη σύνταξει Ptolemaei versabatur [Crucigerus]: ubi cum animadverteret Alphonsinas tabulas conditas ex certis observationibus ante annos fere trecentos discrepare e Ptolemaicis, nec illas tamen cum nostri temporis observationibus congruere, valde optare coepit emendationem tabularum […]." ([Creuziger] was engaging with Ptolemy's *Almagest* when, upon noticing that the Alphonsine tables—compiled from observations made nearly three hundred years earlier—differed not only from those of Ptolemy but also from more recent observations, he began to strongly desire a correction of the tables).

[23] See the *Diploma Caesareum* appended to the beginning of the *Prutenic Tables* (in both the 1551 and 1571 editions), and Caspar Peucer's testimony, cited and translated into English in Gingerich, *op. cit.* (Note 1), p. 366, col. b.

[24] See E. Reinhold, *Commentarius in opus Revolutionum Copernici* (Staatsbibliothek zu Berlin, collocation Ms. lat. fol. 391). The commentary is transcribed (albeit not perfectly) in N. Copernicus, *Gesamtausgabe* VIII/1: *Receptio Copernicana. Texte zur Aufnahme der copernicanischen Theorie* (Berlin: Akademie Verlag, 2002), pp 189–358. A scanned copy can be viewed online: https://digital.staatsbibliothek-berlin.de/werkansicht?PPN=PPN745595367&PHYSID=PHYS_0005&DMDID= (accessed 20 June 2025).

[25] Reinhold, *op. cit*. (Note 24), f. 6v. Transcribed in Copernicus, *Gesamtausgabe* VIII/1 (Note 24), p. 196: "Annus autem vertens seu tropicus seu naturalis seu temporarius variatur ob 4 causas: / 1. Ob mutationem inaequalem sectionum aequinotialium, / 2. on inaequalem motum [Solis] in Zodiaco propter ἐκκεντρότης, / 3. ob mutationem Eccentricitatis, / 4. ob mutationem Apogei."

[26] See. A. Birkenmajer, *op. cit*. (Note 4), pp. 176–177.

[27] T. Brahe, *Opera Omnia* VI: *Epistolae Astronomicae*, ed. E.I.L. Dreyer (Copenhagen: in Libraria Gyldendaliana, typis Nielsen & Lydiche, 1919), pp. 156–157: "De Hypothesibus quoque tuis novis, quarum 8 capit. facis mentionem, te non per omnia assequor. Ipse quidem, cum Elementa mea Astronomica conscriberem, eodem modo Lunam deinde Solem circa Terram constituebam, sed in Homocentrepicyclepicyclis. In centro vero maioris et primi Epicycli Solis rursus Homocentrepicyclepicyclos reliquorum Planetarum, ita ut centrum Homocentricorum in reliquis Planetis idem semper esset cum centro maioris Epicycli Solis, unaque per medium Solis motum in Homocentrico Solis circumduceretur. Sed id non novam rationem faciebam, sed prorsus secundum Copernicum, nec ut conversim per omnia Hypotheses Copernici ad mobilitatem Soli transferrem aliter facere poteram: videbamque eam rationem et Rheticum et Reinholdum intellexisse."

[28] See C. Schofield, "The geoheliocentric mathematical hypothesis in sixteenth-century planetary theory," *The British Journal for the History of Scienc*e, 2 (1965), 291–296.

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[29] See A. Birkenmajer, *op. cit*. (Note 4), pp. 173–175.

[30] *Prutenicae tabulae* (Note 11), *Praefatio autoris in Prutenicos canones coelestium motuum*: "Primum igitur Copernici observationes cum Ptolemaei et aliorum contuli quam accuratissime, ac praeter nudas observationes, et demonstrationum vestigia aliud quidem nihil sumpsi a Copernico, sed canones tum aequalium motuum, tum prosthaphaereseon, tum reliquos denique omnes de novo condidi, in quorum etiam nonnullis aliam prorsus rationem secutus sum, quam iudicavi esse maxime convenientem. Causa vero et rationem singularum compositionum exposui in commentariis nostris, quos scripsi in opus revolutionum Copernici." I have revised and corrected the translation of the last sentence provided in Gingerich, *op. cit*. (Note 4), p. 240. The same sentence is also quoted in A. Birkenmajer, *op. cit*. (Note 4), p. 173.

[31] Cf. *Prutenicae tabulae coelestium motuum authore Erasmo Reinholdo* (Tubingae: Apud Osuvaldum et Georgium Gruppenbachius, 1571), Munich, Bayerische Staatsbibliothek, 4 Eph.astr. 110. This copy will henceforth be referred to as *Prutenicae tabulae*, Munich, 4 Eph.astr. 110.

[32] *Prutenicae tabulae*, Munich, 4 Eph.astr. 110, *Logistice scrupulorum astronomicum*, f. 2r: "[…] Prutenicae tabulae: quas adiuti liberalitate inclyti Ducis Borussiae magno sane et difficili labore longi temporis condidimus, collatis inter se accurate observationibus priscis et recentibus, *quemadmodum alibi haec demonstravimus*. Iam exi his omnibus manifestum est, inquisitionem coelestium motuum, fieri absque numerorum doctrina atque exercitio non posse." Emphasis mine.

[33] Cicero, *Cato Maior de Senectute*, 49: "Si vero habet aliquod tamquam pabulum studi atque doctrinae, nihil est otiosa senectute iucundius. Videbamus in studio dimetiendi paene caeli atque terrae C. Galum, familiarem patris tui, Scipio. Quotiens illum lux noctu aliquid describere ingressum, quotiens nox oppressit, cum mane coepisset! Quam delectabat eum defectiones solis et lunae multo ante nobis praedicere" (And indeed if it has any provender, so to speak, of study and learning, nothing is more enjoyable than a leisured old age. Scipio, I used to see your father's intimate friend, Gaius Gallus, engaged in the task of measuring, almost bit by bit, the heavens and the earth. How often the morning sun has surprised him working on some chart which he had begun at night! and how often night has surprised him at a task begun at the break of day! How much joy he took in telling us, long in advance, of eclipses of the sun and moon!). English translation by W.A. Falconer, in Cicero, *De Senectute, De Amicitia, De Divinatione* (Cambridge, Mass.: Harvard University Press 1923).

[34] *Prutenicae tabulae*, Munich, 4 Eph.astr. 110, front flyleaf: "qui tabulas prutenicas [per…?] [volet?] discere, eum oportet adiungere Copernicum. Nam ex his fundamentis sunt extructae."

[35] The notation "18g" next to "Witembergae" may indicate the price of the book (18 *Gulden*). As one reviewer rightly noted, it is possible that this passage was written by a different annotator. However, certain elements—such as the diphthong "ae"—lead me to believe that the hand is likely the same.

[36] *Prutenicae tabulae*, Munich, 4 Eph.astr. 110, after *Correctura*: "Ipse Deus metas annorum condidit arte, / Quas oculis simul, ac mente notare iubet, / Ut vox e coelo, quae prima sit edita, constet, / Et quando gnotus prodiit ipse Dei / Ille dies et quando instet, quae laeta triumphos / Omnibus ostendet maxime Christe tuos. / φιλιππος."

[37] *Ephemerides duorum annorum 50. et 51. supputatae ex novis tabulis astronomicis per Erasmum Reinholdum Salvedensem ad meridianum Wittebergensem* (Tubingae: per Ulricum Morhardum, 1550), prefatory letter: "Ne mireris, nostros numeros motuum saepeplurimum discrepare ab usitato calculo Alphonsinorum, quem res ipsa ostendit amplius cum observationibus non congruere. Etsi autem decrevimus rationem huius calculi aliquando post exponere, et fundamenta ipsa monstrare: quae plurima quidem sumpsimus a viro clarissimo Nicolao Copernico, qui in hoc ipso genere coelestis doctrinae non fuit inferior Ptolemaeo, tamen periti harum artium, cum coelum accuratius aspexerint, experientur nostrum calculum ad veritatem quam proxime accedere."

[38] J. Evans, *The history and practice of ancient astronomy* (New York, NY: Oxford University Press, 1998), p. 422.

[39] J. Evans, *op. cit.* (Note 38), p. 423.

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[40] Cf. Duhem, *op. cit.* (Note 3), pp. 70–74; A. Birkenmajer, *op. cit*. (Note 4), p. 175: "[Reinhold] observe la plus parfaite neutralité sur le problème du géocentrisme ou héliocentrisme. On peut dir qu'au fond son attitude envers ce dilemne ne diffère pas de celle prise par André Osiander dans la préface bien connue *Ad lectorem de hypothesibus huius operis*"; Gingerich, *op. cit.* (Note 4), pp. 234–235: "A careful reading of Reinhold's printed works shows that the Wittenberg astronomer must have been in close agreement with the anonymous introduction added to *De revolutionibus* by Andreas Osiander, which stated that the 'hypothesis need not be true nor even probable; if they provide a calculus consistent with the observations, that alone is sufficient.' Reinhold, like Osiander, saw the task of the astronomer as a model-making." See also Lerner, *op. cit.* (Note 15), p. 445, n. 147, which reminds the reader that Reinhold sent the *Prutenic Tables* to Osiander. As one of the anonymous reviewers rightly observed, the portrayal of Osiander as an "instrumentalis" warrants reconsideration. I intend to address this issue in a subsequent, more comprehensive study.

[41] Westman, *op. cit*. (Note 4), pp. 174, 181. See also Westman, *The Copernican Question* (Note 15), pp. 141–170. It should be noted that Westman's position is more nuanced than those of Duhem, A. Birkenmajer, and Gingerich (see p. 167).

[42] See, for instance, Kusukawa, *The transformation of natural philosophy* (Note 8), pp. 134–144; Methuen, *op. cit*. (Note 8).

[43] *Prutenicae tabulae* (Note 11), *Diploma Caesareum concesso Erasmo Rheinholt Salvedensi*: "Cum igitur per homines fide dignos et viros praecipuos ad nos relatum esse, nostrum et sacri Imperij fidelem dilectum Erasmum Rheinholt Philosophiae Magistrum, non solum praeclare eruditum esse in Mathematum doctrina, sed etiam utiliter reipublicae in his artibus docendis servire […]." On the privilege, see also Westman, *The Copernican Question* (Note 15), p. 156 col. a, 158, coll. a-b.

[44] *Prutenicae tabulae* (Note 11), *Logistice scrupulorum astronomicorum*, f. 1v: "Geometria utranque huius Philosophiae partem potissimum gubernat…" Here, Reinhold closely follows the wording used by Melanchthon to describe arithmetic as a necessary discipline for reaching "that most important part of Philosophy about celestial matter" (*ad illam praestantissimam Philosophiae partem de rebus coelestibus*); cited in Kusukawa, *The transformation of natural philosophy* (Note 8), p. 139, n. 90. In both cases, astronomy is regarded as "part of philosophy."

[45] See Duhem, *op. cit*. (Note 3), pp. 73–74: "So geometry is in charge of both parts of *astronomy* […]" (emphasis mine.

[46] On this, see Omodeo, "*Utilitas astronomiae* in the Renaissance: The rhetoric and epistemology of astronomy," in M. Valleriani (ed.), *The Structures of Practical Knowledge* (Cham: Springer, 2017), pp. 307–331, esp. pp. 310–312.

[47] See Kusukawa, *The transformation of natural philosophy* (Note 8), pp. 138–139.

[48] Reinhold, *Ptolemaei Mathematicae constructionis Liber primus graece et latine editus* (Wittebergae: ex officina Iohannis Lufft, 1549), prefatory letter, [A6r]: "Quanta vero dulcedo est, videre mirandam certitudinem doctrinae numerorum, et geometricae, et considerare, quomodo magnitudines corporum coelestium, et terrae, et motuum spacia, et alia multa in numeratione et mensuris, proportionum vestigijs reperiantur, quae non sunt pervia sensui, sed mens eo penetrat. Ut Plato dixit, duas alas, numerorum et figurarum, scientiam additas esse menti humanae, quae eam in coelum subvehant" (How great the delight in witnessing the marvelous certainty of the teachings of numbers and geometry! And in reflecting on how the sizes of celestial and earthly bodies, the spaces of their motions, and many other things are revealed in counting and measuring, through the traces of proportions—things inaccessible to the senses, yet grasped by the mind. As Plato said, two wings, the knowledge of numbers and of figures, have been added to the human mind, which carry it up into the sky).

[49] *Theoricae novae* (Note 13), prefatory letter: "[…] ars integra [astronomiae] discenda est ex Ptolemaeo" (The complete sciuence [of astronomy] must be studied from Ptolemy); "Nec demonstrationum acervos ex Ptolemaeo addidi, quas utilius est ab ipso Ptolemaeo disci, qui iis, qui se Philosophiae studiis dedunt, integer cognoscendus est" (Nor have I added the many demonstrations from Ptolemy, since it is more beneficial to

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learn them directly from Ptolemy himself, who must be thoroughly known by all who devote themselves to the study of philosophy).

[50] See Duhem, *op. cit*. (Note 3), pp. 5–24.

[51] *Theoricae novae* (Note 13), preface: "Quod autem hoc pacto magnus coelestium orbium numerus colligitur, id arti vel potius imbecillitati nostri intellectus condonandum est. Etsi enim haec septem ac pulcherrima corpora divinitus etiam fortassis sine huiusmodi orbibus eam vim insitam habent, ut aliud in alia varietate ac irregularitate motuum suam conservet legem atque perpetuam harmoniam, nobis tamen sine his orbibus, saltem rationabiliter, eam, ut ita dicam, harmoniam irregularitatis animo complecti, ac cogitando persequi perdifficile fuerit." I have slightly modified the English translation provided in P. Barker and B.R. Goldstein, "Realism and instrumentalism in sixteenth century astronomy: a reappraisal," *Perspectives on Science*, 6 (1998), 232–58, p. 236.

[52] See especially N. Jardine, "Scepticism in Renaissance astronomy: A preliminary study," in R.H. Popkin and C.B. Schmitt (eds.), *Scepticism from the Renaissance to the Enlightenment* (Wiesbaden: Harrasowitz, 1987), 83–102, pp. 87–88; and Barker and Goldstein, *op. cit.* (Note 51), p. 236. E.J. Aiton, "Celestial spheres and circles," *History of Science*, 19 (1981), 75–144, pp. 99–100, partially upholds Duhem's view on Reinhold.

[53] See Barker and Goldstein, *op. cit.* (Note 51), p. 236: "The *theorica* was a teaching tool, and the humanists who introduced the orbs recognized them as aids to thinking about otherwise difficult matters."

[54] *Theoricae novae* (Note 13), preface: "Multo minus duxi infarciendas esse disputationes physicas, ut alij quidam fecerunt. Quid est enim insulsius, quam inventa geometrica exagitare coniecturis physicorum? Non solum vanitas est ingenij, ut Plato dixit, sed etiam petulantia digna odio, conturbare geometricas demonstrationes praestigijs coniecturarum" (I was even less inclined to fill the work with physical disputations, as some others have done. For what is more absurd than to distort geometrical findings with the conjectures of physicists? It is not only a vain display of wit, as Plato said, but also a kind of insolence worthy of contempt, to disrupt geometrical demonstrations with the tricks of conjecture).

[55] On the status of astronomy in the Renaissance, see R.S. Westman, "The astronomer's role in the sixteenth century: a preliminary survey," *History of Science*, 18 (1980), 105–147; N. Jardine, "The places of astronomy in early-modern culture," Journal for the History of Science, 29 (1998), 49–62; I. Pantin, "L'astronomie et les astronomes à la Renaissance: les facteurs d'une mutation," *Nouvelle Revue du XVIe Siècle*, 20 (2002), 65–78.

[56] Barker and Goldstein, *op. cit.* (Note 51), p. … This definition has already been convincingly criticized; see R.L. Kremer, "Copernicus amonf the asterologers: A preliminary study," *Algorismus*, 59 (2006), 225–52, p. 245. I am grateful to the anonymous reviewer for drawing my attention to this study.

[57] See, for instance, Melanchthon, *Initia doctrinae physicae* (Witebergae: per Iohannem Lufft,1550), f. 46r: "Oculi nobis octo sphaeras monstrant" (The eyes show us eight spheres).

[58] Contrary to Westman, *op. cit.* (Note 55), p. 113, and Aiton, *op. cit*. (Note 53), pp. 99–100, I believe that Reinhold's reference to the Aristotelian concept of solid celestial spheres added in the 1553 edition of his commentary on Peurbach's *Theoricae novae planetarum* should be understood not as a statement of his own beliefs, but simply as an exposition of the theory.

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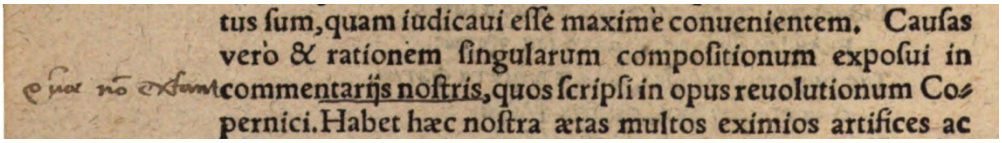

tus ſum, quam iudicaui eſſe maximè conuenientem. Cauſas
verò & rationem ſingularum compoſitionum expoſui in
quæ nō extant commentarijs noſtris, quos ſcripſi in opus reuolutionum Co-
pernici. Habet hæc noſtra ætas multos eximios artifices ac

Figure 1. Detail from the 1571 edition of the *Prutenic Tables* held in Munich, Bayerische Staatsbibliothek, 4 Eph.astr. 110, Preface.

594x80mm (72 x 72 DPI)

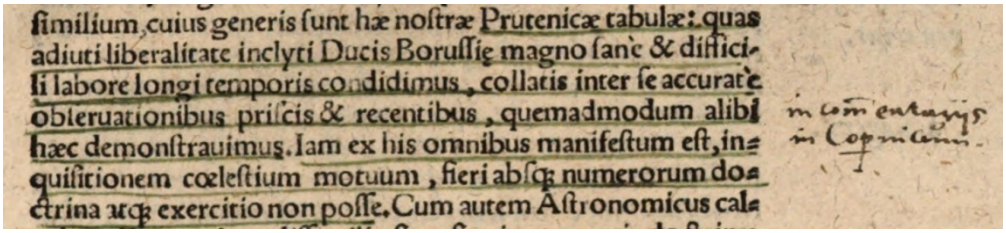

similium, cuius generis sunt hæ nostræ Prutenicæ tabulæ: quas
adiuti liberalitate inclyti Ducis Borussię magno sanè & difficili labore longi temporis condidimus, collatis inter se accuratè
obseruationibus priscis & recentibus, quemadmodum alibi
hæc demonstrauimus. Iam ex his omnibus manifestum est, in-
quisitionem cœlestium motuum, fieri absq; numerorum doctrina atq; exercitio non posse. Cum autem Astronomicus cal-

Figure 2. Detail from the 1571 edition of the *Prutenic Tables* held in Munich, Bayerische Staatsbibliothek, 4 Eph.astr. 110, f. 2r.

515x115mm (72 x 72 DPI)

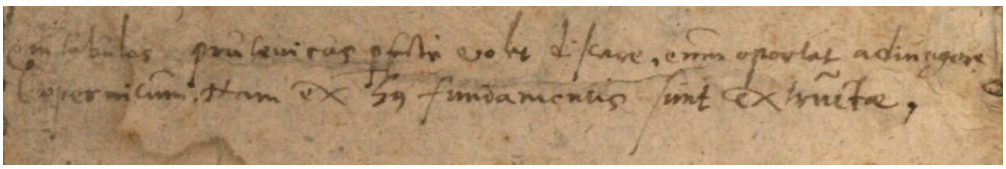


Figure 3. Detail from the 1571 edition of the *Prutenic Tables* held in Munich, Bayerische Staatsbibliothek, 4 Eph.astr. 110, front flyleaf.

582x92mm (72 x 72 DPI)

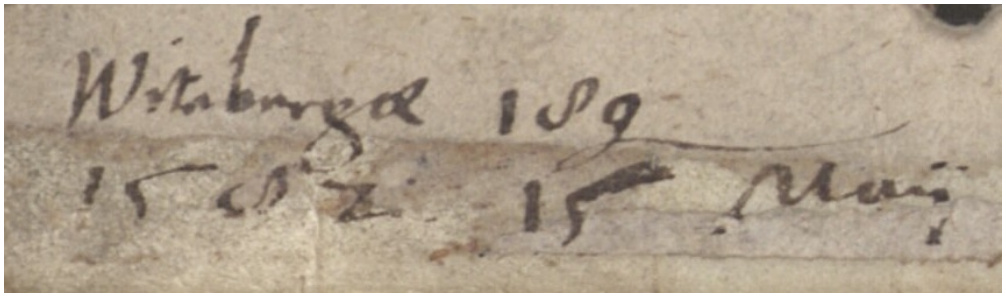


Figure 4. Detail from the 1571 edition of the *Prutenic Tables* held in Munich, Bayerische Staatsbibliothek, 4 Eph.astr. 110, front flyleaf, lower-left corner.

302x87mm (72 x 72 DPI)