THE DISPUTATIONAL CULTURE OF RENAISSANCE ASTRONOMY: JOHANNES REGIOMONTANUS'S "AN TERRA MOVEATUR AN QUIESCAT"[1]

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In 1533, an excerpt from a disputation on the motion of the Earth, entitled *An Terra moveatur an quiescat… disputatio* [Disputation on whether the Earth Moves or Rests], was printed in Nuremberg and attributed to none other than the highly respected 15th-century astronomer Johannes Regiomontanus. It tackled a crucial issue of the event known as the "Astronomical Revolution" or "Copernican Revolution," which was ignited by the publication of the first modern mathematical proposal of a heliocentric astronomy (that is, Nicolaus Copernicus's *De revolutionibus orbium coelestium*).[3] However, the connection of the printing of the disputation with Copernicus's planetary theory is not an obvious one. First, the disputation refuted terrestrial motion. Second, Nicolaus Copernicus's geokinetic and heliocentric reform of astronomy had not been completed by 1533. His major work, the aforementioned *De revolutionibus orbium coelestium* [On the Revolutions of the Celestial Spheres], would only be printed ten years later (also in Nuremberg, in 1543). Third, this scholastic *disputatio* does not seem to be the best candidate for a *ballon d'essai* aimed at preparing the learned community for one of the most controversial issues of Renaissance astronomy and natural philosophy. Its modest profile does not bear comparison to epoch-making disputations that sparked famous philosophical, theological and political polemics such as Pico della Mirandola's 900 theses or Martin Luther's Wittenberg theses. As a matter of fact, the developments in mathematical astronomy ranging from Copernicus to Galileo Galilei and Johannes Kepler have often been considered external to—if not openly in conflict with—the scholastic philosophy of the universities, of which the disputation was a typical genre. However, if we consider the cultural contexts of Renaissance science, especially the relevance of humanistic networks and university

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[3] Cf. Kuhn T.-S., *The Copernican Revolution. Planetary Astronomy in the Development of Western Thought* (New York: 1959).

intellectual life, we will be able to appreciate several circumstances that connect the printing of 1533 to the first reception of Copernicus.

The disputation *An Terra moveatur an quiescat* appeared as a chapter within a larger work. Mathematician Johannes Schöner[4] (1477–1547) inserted it into his book on geography that bore the generic title *Opusculum geographicum* [Geographical Booklet] (Nuremberg 1533), a work that offered an overview of cosmographic themes.[5] The *opusculum* is arranged into two parts: the first one provides the general premises of geography, such as establishing the spherical form of the Earth and its immobility; the second one deals with the geographical divisions of the Earth, their denominations and up-to-date geographical coordinates.[6]

Schöner printed the disputation in the first part (as the second chapter) and attributed it to Regiomontanus, who was regarded at that time as the most important mathematical astronomer of the earlier generation. The attribution seems reliable to us, in consideration of the fact that it was Regiomontanus's intellectual heirs who edited the text in the town (Nuremberg) where his legacy was alive and where his library and manuscripts were preserved.[7] It was printed by Johannes Petreius, then renowned for the quality of his scientific publications. Today, he is principally remembered for the *editio princeps* of Copernicus's *De revolutionibus*. Petreius received the manuscript of the book that revolutionized planetary theory from the young Wittenberg professor of mathematics—and Copernicus's pupil—Georg Joachim Rheticus. They must have met in 1538 when Rheticus paid Schöner and his scientific circle a visit in Nuremberg.[8] On that occasion, Schöner persuaded him to travel to Polish Varmia and meet Copernicus in order to receive the details of his work and conceptions first-hand.[9] As a matter of fact, rumors about Copernicus's geokinetic and heliocentric project of astronomical reform had spread across Europe from Poland since 1514 at the latest. In that year, cosmographer Maciej of Miechów recorded Copernicus's preparatory booklet, which is known today as *De hypothesibus motuum coelestium commentariolus* [Brief commentary on the Hypotheses of Heavenly Motions], in the catalogue of his library.[10] Rheticus wrote the very

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[4] Cf. Entry "Schöner, Johannes" in *Allgemeine Deutsche Biographie*, vol. 32, by Schmeidler F., 405–406.

[5] The original, full title reads as follows: *Ioannis Schoneri Carolostadii Opusculum Geographicum ex diversorum libris ac cartis summa cura et diligentia collectum*, *accommodatum ad recenter elaboratum ab eodem globum descriptionis terrenae*.

[6] *Prima pars principalis huius opusculi, de rotunditate terrae*, *de circulis Sphaerae*, *in terrae globo etiam intellectu constitutis*; *Secunda pars principalis huius opusculi*, *de generali ac particulari divisione nostrae habitabilis*, *secundum recentiores cum Geographos tum Hydrographos*.

[7] Regiomontanus, *Opera Collectanea*, ed. Schmeidler F. (Osnabrück: 1972) XIII–XIV.

[8] Kraai J., "The Newly-found Rheticus Lectures", in *Beiträge zur Astronomiegeschichte* 1 (1998) 32–40.

[9] Włodarczyk J., *Introduction* to Georg Joachim Rheticus, *Narratio prima or First Account of the Books* On the Revolutions *by Nicolaus Copernicus* (Warsaw: 2015) 9–70, especially 13.

[10] Biskup M., *Regesta copernicana (Calendar of Copernicus' Papers)* (Wrocław: 1973) 63–64, n. 91.

first report on the novel planetary theory, entitled *Narratio prima* (Danzig 1540), and acknowledged Schöner by dedicating the work to him.

These elements are enough to trigger the interest of any historian of Renaissance astronomy, despite the fact that Regiomontanus's disputation on terrestrial motion is short and rather unsurprising. The fact that the motion of the Earth, which was the most unconventional thesis brought forward by Copernicus, could be presented to a learned readership in the form of a *disputatio* invites us to reconsider the scholastic entanglements of Renaissance science—or, in other words, the connections between the new science and university culture. This interest in the educational roots of science is not unprecedented: for instance, seminal works in historical epistemology such as those by Ludwig Fleck and Thomas Kuhn, *Entstehung und Entwicklung einer wissenschaftlicher Tatsache* (1935) and *On the Structure of Scientific Revolutions* (1962), have already stressed the importance of teaching and its forms to adequately understand the science of the present and the past. Studies on the connections between science and universities have flourished, especially in recent years in the wake of Charles Schmitt's work, which advocated the study of Italian-university Aristotelianism in order to gain an adequate comprehension of Western intellectual history.[11]

This essay focuses on Regiomontanus's disputation about the immobility or the motion of the Earth because it has only received scant attention thus far. We would like to call the attention of intellectual historians to this singular 15th-century astronomical disputation that addresses such a *vexata quaestio*. First, its scholastic style means it is illustrative of the encounter between established modes of scientific practice and novel outlooks. Regiomontanus's persona is also exemplary of such an encounter between tradition and innovation: he is at once the classicist-mathematician, the humanistic erudite personality, the university lecturer and the editorial entrepreneur. Second, Regiomontanus's text constitutes a rare piece of evidence involving European university culture in its transition from a manuscript culture to a printed one.

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[11] Schmitt C., *Studies in Renaissance Philosophy and Science* (London: 1981). For an institutional history of English scientific culture see Feingold M., *The Mathematicians' Apprenticeship: Science, Universities and Society in England 1560-1640* (Cambridge: 1984). On Jesuit colleges in early modernity, see Romano A., *La contre-réforme mathématique: Constitution et diffusion d'une culure mathématique jésuite à la Renaissance* (Rome: 1999), Baldini U., *Saggi sulla cultura della Compagnia di Gesù (secoli XVI-XVIII)* (Padua: 2000) and Hellyer M., *Catholic Physics: Jesuit Natural Philosophy in Early Modern Germany* (Notre Dame, Ind.: 2005). On the scientific culture of the protestant universities in early modernity see, among others, Omodeo P.-D. with Friedrich K. eds., *Duncan Liddel (1561–1613): Networks of Polymathy and the Northern European Renaissance* (Leiden: 2016).

The text and the arguments of the disputation

In this section, we offer the reader our translation of Regiomontanus's text with comments. The original text is edited in Felix Schmeidler's facsimile edition.[12] We transcribed the text from the *Opusculum geographicum* and compared it with Schmeidler's edition. As has been stated, the disputation originally appeared as the second chapter of Schoener's Schöner's geographical work; it followed an introductory chapter in which the sphericity of the Earth is justified with arguments derived from Ptolemy's *Almagest* Book 1 and Theon Alexandrinus's *Commentary to the Almagest*.[13] The disputation begins as follows:

> *An Terra moveatur an quiescat, Ioannis de Monte regio disputatio. Caput II.*
> *Quod moveatur, quia per motum terrae circularem ab occidente in orientem omnia salvari possunt, quae in astris apparent. Igitur si dicimus terram moveri et coelum quiescere, nullum apparet inconveniens. In oppositum est autor Sphaerae. Nota quaestio quaerit de motu locali, et non de motu alterationis, sive generationis et corruptionis. Quaerit itaque an terra localiter moveatur: de quo quidam antiqui opinati sunt, quod coelum quiesceret, et terra moveretur super polis suis circulariter, in die faciendo unam revolutionem ab occidente versus orientem. Ita imaginabantur, quod terra haberet se sicut assatura in veru, et Sol sicut ignis assans. Dicebant enim: Sicut ignis non indiget assatura, sed e converso, ita Sol non indigeret terra, sed potius terra Sole.*

> Johannes Regiomontanus's Disputation on whether the Earth Moves or Rests
> One can argue that the Earth moves because all heavenly phenomena can be saved through the circular motion of the Earth from West to East. Therefore, if we say that the Earth moves and that the heavens are at rest, everything appears to hold together. The author of the *Sphaera* holds the contrary view.
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> A well-known question [*quaestio*] concerns local motion [from place to place] – not the motion of alteration, that is, of generation and corruption – but precisely whether the Earth moves [*moveatur* = is moved] by local motion. Some ancients already argued that the heavens were at rest and the Earth moved circularly around its poles, daily accomplishing a rotation [*revolutio*] from West to East.
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> On this account it was thought that the Earth was like roasted meat on a spit, and that the Sun would roast it like the fire. They argued indeed that, as the fire does not long for the roasted meat, similarly it is not the Sun that longs for the Earth, but rather the Earth for the Sun.

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[12] Regiomontanus, *Opera Collectanea*, 37–39.
[13] Schöner, *Opusculum geographicum*, 3r.

Here Regiomontanus presents terrestrial motion as a well-known problematic. In fact, the Earth's rotation and its displacement from the centre of the cosmos had been dealt with and refuted by the most important authors of mathematical astronomy and celestial physics in Antiquity, Aristotle and Ptolemy. The need for such refutation indirectly testifies that several philosophers embraced terrestrial motion in Antiquity. Timaeus the Pythagorean defends the thesis that the Earth rotates around its axis in the dialogue that is named after him (Plato, *Timaeus*, 40b–c). Aristotle later dismissed such a "Pythagorean" doctrine together with another cosmological view of the same origin according to which the Earth moves around a "central fire" from which it receives light and warmth (Aristotle, *De coelo* II,13). The name of other ancient supporters of terrestrial motion was inferred from classical sources. Copernicus mentions Philolaus the Pythagorean, who allegedly taught his astronomical theories to Plato, Hiketas of Syracuse, Herakleides of Pontus and Ekphantus the Pythagorean.[14] Archimedes referred to the heliocentric system of Aristarchus in the *Sand Reckoner* without offering any details of the theory.[15] However, Regiomontanus refers to the topic of the Earth's motion as a *quaestio,* alluding to his scholastic context or even projecting a typical scholastic genre onto the ancient past.

The "autor *Sphaerae*" in the quoted passage most likely refers to Sacrobosco, who was the standard source for spherical astronomy in medieval universities; it could also refer to Regiomontanus's favourite introduction to the same subject written by the Islamicate astronomer Alfarghani. These works resumed standard arguments derived from the first book of the *Almagest*.[16] University exercises, *quaestiones* and *disputationes* on spherical astronomy which were based on such sources had to deal with the question of the motion of the Earth.

Famous medieval *magistri* also discussed the topic and devised new arguments *pro* and *contra*. They also embedded such discussions in new conceptual frameworks. The most studied sources are John Buridan's *Quaestiones super libris quattuor de caelo et mundo* [Questions on

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[14] Aujac G., "Le géocentrisme en Grèce ancienne?," in Semaine de Synthèse, *Avant, avec, après Copernic: La représentation de l'Univers et ses conséquences épistémologiques* (Paris: 1975) 19–28.

[15] Dijksterhuis E.-J., *Archimedes* (Copenhagen: 1956) 360–373, Chap. XII, "The Sand-Reckoner."

[16] As one can read in a Renaissance edition of Alfarghani: Alfraganius, *Chronologica et astronomica elementa, e Palatinae bibliothecae veteribus libris versa, expleta, et scholiis expolita*, ed. Iacobus Christamannus (Frankfurt/Main: 1590) Chap. IV: *Quod terra sit centrum universi et sese instar puncti habeat respectu coeli*, p. 21: *Neque terra movetur. Si enim perpetuo descendendo moveretur*, *tunc res levis ut stipula aut palea nunquam eam assequeretur*, *ipsa enim utpote res gravis citius descenderet. Si autem in latera volutaretur*, *sagitta directo a capite in coelum eiecta*, *non recideret in eundem locum*. *Neque avis e nido suo egressa ad eundem redire posset*, *quoniam terra velocius moveretur. Si autem terra perpetuo ascendendo moveretur*, *non haberet naturam elementarem*, *ex frigido*, *sicco*, *calido et humido constantem*. *Sed hoc adverstaur placitis antiquorum philosophorum*.

the Four Books on the Heavens and the World] and Nicole Oresme's *Le livre du ciel et du monde* [Book on the Heavens and the World].[17] Using a purely optical viewpoint, they argued that the motion of the 'observer' (we on the Earth) and that of the 'observed thing' (the heavens) are equivalent. One of Buridan's arguments in favour of terrestrial motion is based on the nobility of the heavens, and draws upon the ancient Greek conception that the noblest state is being at rest. According to Buridan, this characterizes the highest celestial sphere of the fixed stars. By contrast, the lowest realm of the Earth is affected by motion. Notwithstanding this opinion, Buridan ended up dismissing terrestrial rotation due to "physical" considerations. Both he and Oresme considered whether an inner tendency, called *impetus*, could make terrestrial motion acceptable. Their theory of motion was based on the reworking of the Aristotelian theory of motion by the renowned philosopher of Late Antiquity, John Philoponus. For Buridan, *impetus* is a quantity associated with the matter of the projectile and its speed. In accordance with this concept, the motion of a projectile comes to an end because of its weight and the resistance of air.[18] Impetus is the basis for the perpetual motion of the celestial bodies; according to neo-Platonic views brought forward by Philoponus, it was conceived as a virtue that God conferred upon the celestial bodies in the act of Creation. Although Buridan rejected the well-known Ptolemaic claim that the resistance of the air would make the motion of the Earth impossible, he regarded the argument concerning an arrow vertically thrown in the air as decisive. He argued that it is impossible that the projectile is transported along with the rotating Earth because, as he assumed, it is physically (he actually meant conceptually) impossible that a body suffers two impetus simultaneously when they come from different directions. For Buridan, the non-viability of the composition of motions constituted a postulate that was irreconcilable with the thesis of terrestrial motion. Conversely, Oresme did not reject such a physical limitation, but the irreconcilability of terrestrial motion and scriptural exegesis eventually led him to reject geokinetic views (he mentioned Herakleides Ponticus as an ancient supporter of terrestrial mobility).[19]

Regiomontanus was more cautious than such Aristotelian predecessors in his disputation, which can be seen in the ensuing passage detailing his first thesis or *conclusio prima*. He referred to (apparently well-known) upholders of terrestrial mobility as "isti" (they)

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[17] For an overview: Omodeo P.-D., *Copernicus in the Cultural Debates of the Renaissance*. *Reception*, *Legacy*, *Transformation*, (Boston–Leiden: 2014) 205–209.
[18] Buridanus, *Quaestiones super libros quattuor de caelo et mundo*, ed. Moody E.-A. (Cambridge, MA: 1942; repr. New York, 1970) 226–229.
[19] Oresme N., *Le livre du ciel et du monde*, ed. Menut A.-D. – Denomy A.-J. (Madison–London: 1968), section II, 25.

without expressly naming them. We cannot say whether he was thinking of scholastic masters or ancient authors.

> *Conclusio prima. Terra non movet circulariter ab occidente versus orientem super polis suis et centro motu diurno, ut isti opinabantur. Patet quasi sic difficilius esset ire contra occidentem quam orientem quod est contra experientiam. Oporteret enim aerem terrae vicinum etiam ita moveri, qui esset ambulanti impedimento. Aves etiam non possunt bene volare contra orientem propter aerem insequentem, qui pennas earum elevaret. Nam [non] melius volare videmus aves contra ventum quam cum vento. Item proiectum sursum non rediret in locum a quo exivit. Item aedificia ex tam vehementi impetus viderentur rumpi. Manifestius tamen indicium est quod non moveatur terra motu diurno, in hoc quod aves videntur in sublimi moveri versus orientem, similiter nubes faciunt, quod nequaquam accideret si terra sic moveretur, adeo enim velociter oporteret terram moveri, quod ipsa motu suo superaret motum omnium in sublimi existentium, omnes igitur aves et omnes nubes viderentur moveri versus occidentem.*

First thesis: The Earth has no daily West-East circular motion around its poles and around the centre, as they [*isti*] thought.[20]

This is fairly clear, for it would be more difficult to go westwards instead of eastwards, which is against experience. One would expect that the air near the earth would move in such a way that it would become an obstacle for those who walk. Moreover, the birds could not fly properly towards the East [*contra orientem*] because the air would overtake them and lift their wings up. That is why we see that birds can fly better with the wind [*cum vento*] than against the wind [*contra ventum*].[21] Also, what is thrown upwards would not come back to its point of origin. In a similar manner, we would see the buildings breaking down by means of a very violent impulse [*impetus*].

However, a clear piece of evidence that the Earth does not move [*moveri* = is not moved] by daily motion is that we see the birds moving through the air eastwards [*versus orientem*], and the clouds do the same; this would never happen if the Earth moved in such a way so that it would be moved faster in order to overtake, with its own motion, the motion of all that is in the air. Hence, we would see birds and clouds moving westwards [*versus occidentem*].

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[20] "They" could refer to various ancient authors, for instance Herakleides of Pontos and Aristarchus. The expression in Latin, *isti*, recalls *Almagest* 1, 7, τινες. See Ptolemaeus, *Claudii Ptolemaei opera*, ed. Heiberg J.-L., 2 vols. (Leipzig: 1898–1903) I, 24. See also Neugebauer O., *A History of Ancient Mathematical Astronomy*, 3 vols. (Berlin–Heidelberg–New York: 1975) 2, 694–696.

[21] The Latin text: *Nam* [*non*] *melius volare videmus aves contra ventum quam cum vento* (sic = *cum vento quam contra ventum*). So that it makes sense, we added *non* between *Nam* and *melius*.

This first thesis in support of the immobility of the Earth is reminiscent of arguments by Aristotle in *De Caelo* and by Ptolemy in the *Almagest*—arguments that were dismissed by the scholastics mentioned above. As far as the impossibility of the circular motion of the Earth is concerned, Aristotle's argument in *De Caelo* can be briefly summarized as follows:[22] the motion itself is natural if a whole and its parts share the same tendency. The earth, as an element, tends toward the center of the universe (gravity), and this is in accordance with experience. Therefore, the motion of the Earth would be in contrast with the eternal regularity of nature. Second, terrestrial motion would affect the heavenly appearances, in particular the immobility of the fixed stars.

Ptolemy defends the immobility of the Earth in *Almagest* I,7.[23] In particular, he rejects diurnal rotation, for such a rotation would create atmospheric phenomena contrary to experience. For instance, clouds would be overtaken by the Earth and we would always have a strong wind from East to West.

We would like to stress Regiomontanus's choice of the passive form *moveri* to discuss the motion of the Earth. This is in accordance with the Aristotelian principle that "nothing is moved by itself," a principle that was at the core of scholastic celestial physics (and physics in general). According to this principle, separate intelligences (angelical agents, in some cases) were the external causes accounting for the motion of celestial bodies, that is to say, the spheres deputed to transport the heavenly bodies.[24] Regiomontanus's treatment of the motion of a hypothetical "planetary Earth" does not depart from this crucial principle.

> *Conclusio secunda. Quaelibet pars terrae movetur continue localiter, patet. Nam continue pars arida terrae radio Solari calefit, rarefit et levificatur et multae particulae terrae, et etiam aquae de parte arida deportantur in fluminibus in mare magnum. Unde tunc pars terrae aquis cooperta gravior fit, quae etiam aquae frigiditate condensatur et gravificatur, oportet igitur ut illa pellat aliam sursum tam diu, donec centrum gravitatis totius fiat medium mundi, ad quod sequitur quamlibet terrae portione continue localiter moveri.*

> Second thesis: it is evident that any part of the Earth moves continuously from place to place [*localiter*].

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[22] Omodeo P.-D. –Tupikova I., "Cosmology and Epistemology: A Comparison between Aristotle's and Ptolemy's Approaches to Geocentrism", in Schemmel M., *Spatial Thinking and External Representation*: *Towards a Historical Epistemology of Space* (Berlin: 2016) 145–174.
[23] Pedersen O., *A Survey of the Almagest*, with annotations by Jones A. (New York: 2011), 44.
[24] Grant E., *Planets, Stars, and Orbs: The Medieval Cosmos, 1200-1687* (Cambridge: 1994) 469–487.

In fact, the dry part of the Earth is ceaselessly warmed by the Sun's rays, and is made thin and polished; many small parts of the earth and of the water are also brought from the dry part through the rivers towards the open sea. Hence the part of the earth covered by the water becomes heavier, because it has been condensed and solidified due to coldness. Therefore, it pushes another part upwards until the center of weight [*gravitas*] of the whole [Earth] coincides with the center of the world [*medium mundi*]. As a consequence, any part of the Earth is moved ceaselessly from place to place [*localiter moveri*].

This is another scholastic conception, linked to the so-called thesis of the "little motions" of the Earth. Small displacements of materials on the surface of the terrestrial globe produce imbalances, due to the geological shift of the centre of gravity. This produces little motions in the sphere of the elemental earth aimed to create a new balance.[25]

Sixteenth-century peripatetic philosophers such as Andrea Cesalpino, Galileo's professor in Pisa, continued discussing this topic. In his 1571 *Peripateticae quaestiones* [Peripatetic questions] III, 5 (the chapter on sea tides entitled "*Maris fluxum et refluxum ex motu Terrae non Lunae fieri*"), Cesalpino argued motion was communicated downwards, from the eighth sphere, which is the sphere of the fixed stars, to the various planetary orbs and, eventually, from the most external elements to the internal element in the following order: fire, air, water, earth.[26] In this context, Cesalpino anticipated a famous Galileian argument, that is, that the sea tides are produced by terrestrial motion, in his case by the same one responsible for the precession of the equinoxes.[27]

Regiomontanus's theses are followed by two corollaries. Here is the shorter one:

Correlarium. Non semper eadem pars terrae, manet medium mundi, sed [*a*]*lia et successive.*

Corollary. The same part of the Earth does not always stay in the centre of the world, but another comes in succession, and so on.

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[25] Pierre Duhem discussed these medieval topics in relation to Leonardo da Vinci. See Duhem P., *Études sur Léonard de Vinci* (Paris: 1906–1913), 3 vols., vol. 2, 332–336.

[26] *Iusta etiam ratione motus caeli communicatur omnibus corporibus infra ipsum maxime quidem igni, quia propinquissimus est; minime autem terrae, quia remotissima; medio autem modo corporibus mediis, aeri quidem magis, quia iuxta ignem; aquae autem minus, quia iuxta terram. Nam cum aeterna sint elementa, secundum totas sphaeras non minus quam coelum: motum etiam quendam aeternum habuisse iustum fuit.* From Cesalpino A., *Peripateticae Quaestiones* (Venice: 1571) f. 61r.

[27] See Omodeo P.-D., "Riflessioni sul moto terrestre nel Rinascimento: tra filosofia naturale, meccanica e cosmologia", *Scienze e Rappresentazioni* (2015), 285–299.

This passage recalls the medieval discussion on whether the geometric centre and the gravitational centre coincide. Buridan, for one, gave a negative answer on the grounds that the elements are not distributed equally on the Earth. On this view, the globe is bound to periodical adjustments aimed to continuously restore the coincidence of the geometrical and gravitational centres. Regiomontanus limits his treatment to the motion of the parts. Geological phenomena, such as mountain erosion and earthquakes, redistribute matter and produce constant changes. The subject matter of the second corollary addresses these arguments/points:

> *Correlarium. Stat longo temporis successu, supposita perpetuitate mundi, partem terrae quae quandoque fuit in centro mundi, venire ad superficiem, et contra. Inde habetur occasio magnorum montium et scopulorum, partes enim terrae minus tenaces per pluviam asportantur, et manent partes terrae tenaciores quae successive radiis Solaribus coquuntur, et duriciem maiorem accipiunt. Huiusmodi terrae sportationem si quis nolet credere, videat radices arborum antiquarum in sylvis, videbit enim ea siam terrae supereminentes, quas tamen quondam in terra conditas esse oportuit.*

> Corollary. After a long period of time, if the perpetuity of the world is taken for granted, we see that a part of the earth that for a certain time was at the centre of the world comes to the superficial ground and vice-versa. From this arises the destruction of the great mountains and the rocks, for the less tough parts of the earth are taken away by the rain, while the tougher parts stand still for they are cooked by the Sun's rays and thus are stronger. In the same manner, if someone does not want to believe in the erosion of the earth, let him take a look at the roots of the old trees in the woods, and he will see them coming out of the earth, while, once upon a time, they must have been inside [it].

The passage lists the phenomena that are observable consequences of a sort of elemental cycle of terrestrial matter: the erosion of rocks and mountains, and the emergence of the tree roots. The earth, seen as the heaviest element, is only affected by these adjustments insofar as its parts are always re-adjusted but its central position as a whole is maintained. Local terrestrial motion is thus presented as the motion of the parts but not of the whole.

A summary of the aforementioned theses against circular motion and motion from place to place follows:

> *Sic patet qualiter intelligatur terram esse immobilem, id est non movetur circulariter circa centrum suum, sicut Sphaerae. Etiam ipsa non est ita in continua mutatione locali, propter sui gravitatem sicut caetera elementa, quae leviora sunt et faciliter agitari possunt et moveri.*

> Therefore, it is clear to what extent we mean that the earth stands still, that is, it does not move circularly around its centre, as if it were [the celestial] sphere.[28] Moreover, it is not continuously affected by local alteration owing to its weight, unlike the other elements, which are lighter and more easily bound to agitation and motion.

The refutation of the possible motion of the Earth is strengthened in the last passage of the disputation:

> *Ad rationem negandum quod omnia possint salvari. Nam per hoc non possunt salvari. Coniunctiones et oppositiones planetarum, et diversitates motuum eorum. Sed neque salvari posset, quod videmus aves et nubes quandoque moveri versus orientem imo oporteret eas moveri semper versus occidentem.*

> It is reasonable to refute that all the appearances can be saved. In fact, through it [terrestrial motion] neither the conjunctions nor the oppositions of the planets nor the differences of their motions can be saved. Moreover, we cannot save the fact that we see the birds and the clouds moving sometimes eastwards [*versus orientem*], while they should always be moving westwards [*versus occidentem*].

The motion of the Earth, as Regiomontanus argues, cannot be reconciled to all of the observed appearances. According to Regiomontanus, the heavenly phenomena cannot "be saved" if one takes the geokinetic thesis as a premise. These include conjunctions and oppositions but, as a matter of fact, one could conceive such doubt relative to the latter phenomena only if, in addition to the axial rotation, one assumed a motion that removes the Earth from the cosmological centre. Regiomontanus does not expand on such hypothesis, which would become relevant only later. As Copernicus's work was to argue ten years after the publication of the disputation *An terra moveatur*, the motion of the Earth makes a number of the aspects of planetary theory geometrically intelligible, in particular the retrograde motions of the planets, the elongations of the inferior planets and the ratio between distance and periods of planetary motions. Without the theory of the Earth's mobility these aspects remain obscure and would either require *ad hoc* explanations or an appeal to metaphysical principles, as was the case with pre-Copernican astronomy. Although Regiomontanus was far from acknowledging this, the

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[28] *Sphaera* stands for celestial sphere, the eighth sphere, the topic of the treatises of Sacrobosco and al-Farghani.

very fact that he disputed the issue shows that he deemed it not to be self-evident but to require supporting argumentation.

Finally, the disputation ends, anticipating the next topics to be dealt with:

> *Sic terrae rotunditatem ac immobilitatem* (*quae centrum mundi*) *hoc est omnium elementorum et sphaerarum existit*, *sine ulla distinctione circulorum expressimus*. *Nunc de circuli Sphaerae*, *qui et ipsi in globo terrae quemadmodum et in coelo imaginantur, dicendum venit, et primo de axe mundi*.

> We have dealt with the sphericity and the immobility of the Earth (which is the centre of the world), that is the centre of all elements and of the celestial spheres, without further treatment of the [heavenly] circles. Now it is time to speak about the circles of the celestial spheres, which are depicted in the terrestrial globe as well as in the heavens, beginning with the definition of the axis of the world.

The sphericity of the Earth is actually absent from Regiomontanus's disputation but is treated in chapter 1 of Schöner's *Opusculum*. In the original disputation, the next topic to be addressed was the axis of the world and the heavenly circles. Following this proposal, Schöner dealt with these matters in the chapters succeeding the disputation (chapters 3 and 4) of his *Opusculum*. It is also possible that the last passage does not belong to the 'original' text of the disputation, and can be seen as a bridging passage between chapters. If this is not the case, the disputation was not written down in its entirety and the preliminary discussion of terrestrial sphericity and of the circles of the celestial spheres was part of a larger disputation of which the motion of the Earth constituted only one topic.

The cultural contexts of a Renaissance astronomical disputation on terrestrial motion

Schöner's publication of (a part of) a text by Regiomontanus was perhaps an instrumental move on his part to increase the prestige of his book's argument for terrestrial immobility. In the economy of the *Opusculum geographicum*, it matched Schöner's own discussion of the cosmological arguments that Ptolemy provided in the first book of the *Almagest,* and also reinforced them with a modern authority.

It should be mentioned that prominent scholars have questioned Regiomontanus's authorship of *An Terra moveatur an quiescat*. Ernst Zinner, author of the standard prosopography on Regiomontanus, questioned the attribution of the text. Zinner argued that the disputation was perhaps just a copy that Regiomontanus transcribed in his own hand and that Schöner attributed it to him by mistake or in order to give authority to the discussion of the argument—or both.[29] According to Zinner, it is likely that this text was in the files named *Quaestiones varii* in the catalogue of Regiomontanus's *Nachlass* of 1512.

The disputation *An terra movereatur* most likely served as a source material for a discussion of the topic in Georg Peuerbach and Regiomontanus's *Epytoma in Almagestum Ptolemaei* [Epitome of Ptolemy's *Almagest*]. This is a fundamental source in the history of Western astronomy as it constituted a substantial leap forward in the Latin appropriation of the methods of mathematical astronomy that had been developed in Hellenistic antiquity and the Islamicate world. It constituted the basis for the work of the subsequent generations, including Copernicus. The question of the motion of the Earth was addressed and solved in accordance with Ptolemy and Aristotle in *Epytoma*, Book 1, conclusion 5, which was originally redacted by Peuerbach, Regiomontanus's professor in Vienna:

> *Quod terra localem motum non habeat declarare.*
> *Ex superioribus constat terre non accidere motum rectum. Sic enim medium mundi relinquere cogeretur, quod ante hac prohibuimus. Oporteret denique terram velocissime moveri mole sua id agente, unde reliqua corpora minus gravia terre adiacentia in aere relinquerentur si omnia gravia ad unum niterentur terminum, quod nusquam apparet. Terra demum circularem non habet motum. Si enim circa axem mundi moveretur ab occidente ad orientem, omnia que in aere moverentur semper versus occidentem moveri viderentur. Non enim possent consequi motum terrae. Cuius contrarium in nubibus motis atque avibus sepenumero experimur. Idem quoque accideret: si aerem una cum terra hoc pacto moveri putaveris. Terra postremo circa alium quempiam axem non movetur. Sic enim altitudo poli nobis in terra quiescentibus varia haberetur. Quod cum nemini appareat, terram hac lege moveri non posse constat.*

> Declaration that the Earth has no local motion.
> From the above arguments, it follows that the Earth has no rectilinear motion. It [the Earth] would be forced to leave the centre of the world [*medium mundi*], a possibility that we rejected above. Therefore, it follows that the Earth must move [*moveri*] very swiftly pushed by its own mass [*mole sua id agente*]. Also, if all heavy bodies strove towards the same direction, other, lighter bodies near the Earth would be left back in the air, which never happens.

[29] Zinner E., *Regiomontanus: His Life and Work* (Amsterdam: 1990), 203.

> Moreover, the Earth has no circular motion. If it moved [*moveretur*] around the axis of the world from West to East, all things in the air would always be seen moving [*moveri*] towards the West [*versus occidentem*], which means that they could not take part in the motion of the Earth. We often observe the contrary of this [argument] in the motion of clouds and birds. The same applies to the case in which the air is moved in this way together with the earth. Moreover, the Earth does not move around any other axis. If this was so, we would have a variable height of the poles in the Earth while we are at rest. As this never occurs, it follows that the Earth cannot be in motion in this manner [*hac lege*].[30]

This discussion in the *Epytoma* is closely connected to the *disputatio* against terrestrial motion.

As for Zinner's doubts concerning the attribution, we would like to stress that Schöner was in a privileged position to be informed about Regiomontanus's work and views. He belonged to the community of German astronomers who had learned mathematics from the direct followers and collaborators of Regiomontanus, for instance Bernard Walther. Even though an error of attribution might be possible, we do not see compelling reasons to accept this conclusion. Assuming the text was not penned by Regiomotanus himself, it could well be a report by one of his pupils, who might have written down some notes; it would have been an easy matter for the fame of such a paper to spread easily in the community that continued Regiomontanus's work. However, for us it is less important to secure the paternity of the source than it is to assess its function within the astronomical debates of the sixteenth century.

One of the main goals of the cultural program that Regiomontanus had initiated in Nuremberg was to foster mathematical scholarship through the publication of new works as well as the Latin translation and publication of classics from antiquity and the Islamicate Middle Ages. In order to achieve this, Regiomontanus had opened a printing house in the 1470s. The list of the books he planned to publish is still extant: *Haec opera fient in oppido Nuremberga Germania ductu Ioannis de Monteregio* [These Works Will Be Printed by Johannes Regiomontanus in the Town of Nuremberg, Germany]. The trade list comprised Regiomontanus's unpublished writings, works by authors from classical antiquity such as Euclid, Archimedes, Theodosius and Ptolemy, as well as medieval and recent works, for instance Witelo's optics, Jordanus Nemorarius's *Arithmetica* and Peuerbach's *Theoricae novae planetarum* [New Planetary Theory]. In fact, Regiomontanus also printed Peuerbach's *Theoricae* in 1474 but could not continue his publication program due to an untimely death.[31]

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[30] Regiomontanus, *Epytoma in Almagestum Ptolemaei* (Venice: 1496), f. a6*v*.

[31] See Malpangotto M., *Regiomontano e il rinnovamento del sapere matematico e astronomico nel Quattrocento* (Bari: 2008) 211–217, for an overview of the publication of the books listed in Regiomontanus' Program.

Nonetheless, Nuremberg continued to print scientific works prolifically. The printer Petreius initiated a series that comprised titles from Regiomontanus's list, among them, Regiomontanus's *De triangulis* [On triangles] (1533) and Witelo's *Optics* (1535). Moreover, he printed ground-breakingly novel works that comprised not only Copernicus's *De revolutionibus* (1543) but also many of Girolamo Cardano's most significant writings on astrology (1543), algebra (*Ars magna*, 1545) and universal natural philosophy (*De subtilitate,* 1550). Among other publications, Petreius also printed one of the most famous historical and rhetorical works by Regiomontanus in 1537: the *Oratio introductoria in omnes scientias mathematicas* [Introductory Oration on all Mathematical Sciences]. Regiomontanus had delivered this oration in 1464 in Padua on the occasion of his lectures on Alfarghani's *Sphere*.[32] In Petreius's edition, the *Oratio* served as an introduction to John of Seville's translation of Alfarghani's *Rudimenta astronomica* [Elements of Astronomy] and Plato of Tivoli's translation of Albategnius's *De motu stellarum* [On the Motion of the Stars]. Schöner was in charge of the revision and editing of these texts, at least one of which, *De motu stellarum*, came from Regiomontanus's personal library.

In addition to the close relationship with the Nuremberg intellectual context, the disputation we deal with in this essay is connected to the university contexts of fifteenth-century Europe, including Vienna and Padua. The text of Regiomontanus's disputation on the motion of the Earth probably originates from Vienna, in a university climate in which mathematical and astronomical studies were taught within a curriculum that was centered on rhetoric, logic and philosophy. It is possible that Regiomontanus had the *disputatio* defended in Padua, where he probably lectured in the years 1462–1464.[33] At any rate, we must be careful not to form a narrow image of Regiomontanus the humanist, perceiving him as an intellectual detached from the university culture of his time. According to a schematic vision of the "Renaissance of mathematics" to which Paul Lawrence Rose was particularly committed, the appropriation of classical sources on mathematics and astronomy occurred outside, if not in contrast with, the scholastic culture dominating universities. However, we believe that the *Oratio* is revealing of Regiomontanus's ties to the educational context of universities and his willingness to improve their curricula in order to strengthen the teaching of mathematics.[34]

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[32] Robert Goulding has called it "the first modern history of mathematics." Cf. Goulding R., *Defending Hypatia. Ramus, Saville, and the Renaissance Rediscovery of Mathematical History* (Dordrecht: 2010) 8–10.
[33] Rose P.-L., *The Italian Renaissance of Mathematics. Studies on Humanists and Mathematicians from Petrarch to Galileo* (Geneva: 1975), 90–117.
[34] These topics will be elaborated in the forthcoming paper, Omodeo P.-D., "Johannes Regiomontanus and Erasmus Reinhold: Shifting Perspectives on the History of Astronomy".

The genre of the *disputatio* constituted one of the pedagogic pillars of university culture from the Middle Ages to early modernity. While the *lectio*, and the *quaestio* and the *commentatio* connected to it, were fundamental as far as the transmission, appropriation, comprehension and elaboration of the discussed authors were concerned, the *disputatio* was the crucial instrument of reasoning for purposes as diverse as teaching, the establishment of doctrine and polemics.[35] It has been argued that the *disputatio* offered the most important "method" of clear and logical thought for four centuries, from the twelfth to the end of the seventeenth. As such it was not only appropriate to reassert given truths but also to open up new investigations, especially in natural philosophy and medicine.[36]

The University of Vienna, which Regiomontanus attended, was no exception.[37] Scholarship on the history of that university has documented the extent to which the *disputatio* was practiced.[38] Aristotelian logic and philosophy undoubtedly played a dominant role in the curriculum of the Faculty of Arts. As the records document, the core of the teaching was formed by the *Parva logicalia*, *Physica*, *Metaphysica*, Sacrobosco's *Sphaera* and the *theorica planetarum*. Euclid's Elements was exclusive to the mathematics curriculum, where Book 1 was used in the introductory classes and Books 1 to 5 were used in the more advanced classes on geometry. This curriculum was maintained from the fourteenth century to the fifteenth.[39] The practice of disputation was an integral part of the students' training.[40]

As far as the 'disputability' of fundamental cosmological theses like terrestrial motion is concerned, Olga Weijers, in her solid introduction to the medieval university culture of Paris, has made two important remarks of general relevance relative to disputations. First, "the final answer given by the master of philosophy […] to the questions treated in the disputations was not necessarily seen as the definitive answer to the problem. They [masters and doctors] often display a certain degree of modesty and are ready to change their opinion."[41] Secondly, "the

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[35] Cf. Weijers O., *A Scholar's Paradise: Teaching and Debating in Medieval Paris* (Turnhout: 2015), Chap. 8 "The omnipresent disputation," 121–138.
[36] Lawn B., *The Rise and Decline of the Scholastic 'Quaestio disputata' with Special Emphasis on its Use in the Teaching of Medicine and Science* (Leiden: 1993) 145.
[37] Zinner, *Life and Works*, 13–16.
[38] Kink R., *Geschichte der kaiserlichen Universität zu Wien* (Wien: 1854), vol. 1, part 2, 11; Lhotsky A., *Die Wiener Artistenfakultät*, *1365-1497* (Wien: 1965) 236 and 243; Shank M.-H., "Scientific tradition in Fifteenth-Century Vienna" in Ragep J.-F. –Ragep S., *Tradition*, *Transmission*, *Transformation*: *Proceedings of Two Conferences on Pre-Modern Science Held at the University of Oklahoma* (Leiden: 1996) 117–120.
[39] Cf. Shank, "Scientific tradition", 120.
[40] Cf. Zinner, *Life and Works*, 13: "At Vienna the Bachelor [student] had to demonstrate knowledge of Johannes de Sacrobosco's *De Sphaera,* algebra and the first book of Euclid's *Elements;* the MA candidate also had to know Gherardo da Sabbioneta's theory of planets, perspective [optics], the first five books of the *Elements,* and an arbitrary book of his own choice. In addition, there were mathematical disputations."
[41] Weijers, *A Scholar's Paradise*, 122.

arguments adduced for the opposing position, the position that would be rejected, were of course rebutted, but they were not despised or seen as worthless. On the contrary, they contributed to the discussion, revealed the various aspects of the problem and helped to show why the opposite answer was not valid."[42] In this regard, Regiomontanus's disputation *against* terrestrial motion and the appreciation by his early modern readers appears in a different light than the bare dismissal of the core thesis of Copernican astronomy. Rather, it reveals that the topic was *disputable* and was, in fact, *disputed* in the late Quattrocento and early Cinquecento.

As they have come down to us, Regiomontanus's theses on terrestrial motion are fragmentary. The text seems to be taken from a broader disputation on astronomy, so long as we do not consider its conclusion to be a bridging sentence written by Schöner in order to integrate the fragment in his cosmographic booklet: "Now is the time to speak about the circles of the celestial spheres, which are depicted in the terrestrial globe as well as in the heavens, starting from the definition of the axis of the world." Regiomontanus was dismissive of the standard elementary textbook of spherical astronomy embedded in an Aristotelian physical framework, Sacrobosco. In his Padua *Oratio* he regarded Sacrobosco's book as revealing of the decadence of astronomical studies in the Latin world. He remarked with corrosive irony that in his times the ignorant and the amateurish claimed to be astronomers by reducing the discipline to such a poor book as Sacrobosco's *Sphere*. In Regiomontanus's view, the restoration of mathematical studies in the Latin world had to be renewed by selecting better sources for teaching, for instance Alfarghani, the reference used in his own classes on the subject.[43] In spite of Regiomontanus's limited activity in Padua, his relevance for the consolidation of a scientific culture in that center—something which Copernicus and other students benefitted from—has been often pointed out.[44]

Concluding remarks

Regiomontanus's disputation discusses a major cosmological topic, the mobility of the Earth, in the form of a *disputatio*, which is organized, after a general introduction, in *conclusiones* and

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[42] *Ibid*.

[43] Regiomontanus, *Oratio introductoria in omnes scientias mathematicas*, quoted from *Oratio Iohannis de Monteregio quam habuit ipse Patavii in praelectione Alfragani*, in *Selectissimarum orationum clarissimi viri Domini Philippi Melanchthonis*, vol. 3 (Erphurdiae: Excussit Gervasius Sturmer, 1551), f. 190*r*: "Nunc reliquum est Alfraganum insignem Astronomiae historicum ad limina domus uno verbo salutemus."

[44] Biliński B., "Il periodo padovano di Niccolò Copernico (1501-1503)," in *Scienza e filosofia all'Università di Padova nel Quattrocento* (Padova: 1983) 223–286.

corollaria. Although the text is directed against the motion of the Earth, the theses are conceived as problematic, and thus disputable. Moreover, it is possible that the 'original' disputation was a longer text dealing with spherical astronomy. We would like to emphasize that the genre of the *disputatio* was part of Regiomontanus's educational background. As a student at Vienna and a lecturer at Padua he might well have disputed on the motion of the Earth at a Renaissance university. Given Regiomontanus's criticism of theoretical issues of astronomy, in particular against the drawbacks of Sacrobosco's treatise, no conclusive argument can be given against our acceptance of the attribution of the disputation to him; further, the original disputation might be longer than the one printed in the *Opusculum*. Nevertheless, at present it is impossible to know if the original *disputatio* was oral or written.

The circulation of this disputation is linked to the history of the early reception of Copernicus, in particular the ground-breaking novelty of his defence of terrestrial motion. The disputation specifically addresses this crucial problematic at the threshold of the sixteenth century. The circulation of Copernicus's ideas presupposed the existence of an open-minded group of scholars, such as those who were gathered in Nuremberg. Schöner's decision to put a *disputatio* on the motion of the Earth in his *Opusculum geographicum* is revealing of the positive disposition towards discussions of fundamental problems among sixteenth-century German mathematicians, astronomers and cosmographers. Further, the *disputatio* connects this milieu with the university culture of the time. Schöner preserves the scholastic form of the text. His attribution of the text to Regiomontanus, whether legitimate or not, bears witness to the perceived relevance of the topic. Otherwise, there would be no need to note the prestige of its author. Moreover, Schöner's editorial choice bears witness to the transferral of the question on the motion of the Earth from an oral and manuscript culture, accessible to learned circles and university communities, to the established printing culture of sixteenth-century Germany. Such a transferral is remarkable in as much as it is the earliest occurrence of the discussion of the motion of the Earth in terms of a problematic. In fact, in 1533 Copernicus's *Commentariolus* (first draft) was circulating in a non-printed form, while the *Narratio Prima* appeared only in 1540, and the *De revolutionibus* in 1543.

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Index Nominum

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