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KEPLER'S EARLY PHYSICAL-ASTROLOGICAL PROBLEMATIC

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This paper concerns the origins of Kepler's well-known solar moving power, the physical theory in which a force issuing from the Sun pushes the planets around while attenuating with increasing distance from the centre.[1] That particular representation of a central force, as is well known, played both a heuristic and a justificatory role throughout Kepler's most fundamental astronomical work in planetary theory.[2] Crucial elements were already present in the *Mysterium cosmographicum* of 1596; and, as James Voelkel has rightly emphasized, it is already found in a surviving fragment from Kepler's student disputation of 1593 and thus warrants the view that Kepler was involved in creating a "physical astronomy" from his earliest days at Tübingen.[3]

One important passage from that disputation is already familiar enough from E. A. Burtt's classic *The metaphysical foundations of modern science* where he used it to sustain his view that Kepler was a "sun worshipper" immersed in Florentine Neoplatonic and Neo-Pythagorean philosophy.[4] Later, Thomas Kuhn used Burtt's reading to bolster his contention that scientists sometimes resort to reasons external to science when they embrace a new paradigm.[5] In the passage, Kepler rhapsodized about the Sun as

> producer, conserver, and warmer of all things; a fountain of light, rich in fruitful heat, most fair, limpid, and pure to the sight, the source of vision, portrayer of all colors, though himself empty of colour, called king of the planets for his motion, heart of the world for his power, its eye for his beauty ... the Sun, who alone appears, by virtue of his dignity and power, suited for this motive duty and worthy to become the home of God himself, not to say the first mover.

Contrary to Burtt and Kuhn, however, this passage about the Sun's specialness does not attest to the sorts of reasons that first drew Kepler to Copernicus's theory any more than it would explain why Copernicus himself was initially so attracted to the heliocentric ordering.[6] Instead, it makes more sense that Kepler was already persuaded by Maestlin's reading of Copernicus; and, in the Tübingen disputation, he was developing some original views of his own — reasons that he referred to in the *Mysterium cosmographicum* as "physical, or better yet, metaphysical". So, as early as 1593, he was looking to transfer the primary mover from the outermost sphere to the Sun. And in looking for the properties of a new sort of motive power, he must have been guided by Aristotle's model of a good explanation. In the case of the Sun, that included considerations like the degree of perfection (final cause); heat and light, the stuff of which the Sun was made (material cause); the Sun's

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location at the centre of the world (formal cause); and its capacity to move the planets and generate growth (efficient cause). All these attributes — light-giving, heating, capacity to move — could be found in the Sun, the principal body in the universe. And, when joined to the heliocentric periodicities, one got a single power of nearly infinite motion at the centre which steadily weakened as it moved from the closest to the most distant planets.

This paper attempts to specify more precisely both the local and intellectual conditions that frame the 1593 disputation and in which one finds Kepler's earliest thinking about these issues.

The first question concerns the circumstances of the disputation itself. Academic disputations were highly ritualized performances, always overseen by a *praeses* or master who put questions for disputation to the responding student or *respondens*. In fact, at times the *praeses* provided both the questions and the answers so that the respondent really did just act out the performance.[7] But, for the 1593 event, there is no evidence that this was the case. Kepler was clearly the *respondens*, but who was the *praeses*?

Important recent work by Charlotte Methuen on Kepler's Tübingen period has turned up a salient fact: the professor concerned with natural philosophy in the early 1590s was not Veit Müller, as Max Caspar declared in his biography of Kepler, but Georg Liebler — whom Caspar does not mention at all.[8] From 1552 to 1594, Liebler glossed Aristotle's books on physics and the heavens at Tübingen. His substantial textbook, the *Epitome of natural philosophy*, was organized as a series of questions and answers and effectively constituted the natural pedagogical equivalent of Maestlin's *Epitome of astronomy.*[9] It is a reasonable assumption that Liebler was the *praeses* for the 1593 disputation.[10] Unfortunately, we know nothing further of how this event came about, why the topic was proposed and permitted or how Kepler was chosen to dispute any such propositions. However, even the very fact that such a disputation took place means that Kepler already had enough confidence in Copernicus's geometrical arguments to defend the heliocentric arrangement against *Aristotle* rather than Ptolemy. The distinction is crucial. Just three years after being introduced to the Copernican theory by the mathematics professor Maestlin, Kepler had shifted his own approach from arguments of geometrical/astronomical advantage to arguments based upon the system's claim to some sort of physical reality and metaphysical grounding. If Kepler (as he said in the *Mysterium*) was defending Copernicus's (and Maestlin's) views before the *physics* candidates,[11] he was also beginning to break away from Maestlin's more limited conception of astronomy.[12]

On this question, one suspects that there was more going on in the 1593 disputation than the extant fragment tells us. In arguing *for* the Sun's role as an efficient cause, one would have expected Kepler to dispute *against* the opposite view, namely that the moving power was outside the Sun, such as in the last sphere or in the individual planets. An explicit source of information on planetary movers was contained in Julius Caesar Scaliger's Neo-Aristotelian *Exercitationes*

exotericae, a dense work of propositions and commentary that was popular with Tübingen students around this time and which Kepler mentions that he was familiar with from as early as 1589.[13] Scaliger receives no explicit reference in the 1593 fragment but many years later in his own *Epitome* (*of Copernican astronomy*) Kepler brought up Scaliger's views in something like the way that he could have done in 1593. Scaliger offered up the distinction between a moving power (the efficient cause) and an intelligence (formal and final cause) that guided the form of the planetary motion in time. To yield motion and direction, one might think of the planetary intelligence as a pilot with a map and an intended destination, and a ship and a locomotive source as the material and efficient causes.[14]

Besides Scaliger, Kepler was also confronted with other converging and countervailing developments. Maestlin had a copy of Tycho Brahe's *De mundi aetherei recentioribus* by the summer of 1588.[15] As a student, Kepler already accepted that Tycho Brahe had refuted the existence of solid, impenetrable spheres. And without spheres, what work remained for the moving soul?[16] If spheres and their movers were eliminated, then what of planetary intelligences? The intellective soul, unlike an animal soul, had no capacity to function as an efficient cause because it was a disembodied "mind". As such, it could make sounds and it had a will to act but, even so, it had no capacity to move the planetary globe; and the planet, being an inert body, had no capacity to obey or to move itself. Finally, to ascribe a plurality of souls to the planets was to fall into a decidedly unChristian polytheism.[17]

Of course, one cannot say with certainty that Kepler made all of these arguments in the missing part of his disputation. But it is hard to believe that he would not have taken the trouble to refute Scaliger at the very time when he was most deeply engaged in chewing on Scaliger's exoteric exercises and at the same time that his conviction in the Copernican ordering motivated him to seek in the Sun itself a place for a single moving power.[18]

The exact nature of this power was another matter. Once into the new disciplinary territory of "cosmography" — at least Kepler's sort — the teachings of the best sixteenth-century astronomers — Reinhold, Peucer, Clavius, Praetorius, Brahe, Maestlin — were of little help, because their tools were largely geometrical[19] and Kepler's physical questions were new ones. Was light itself the actual efficient cause of planetary motion? Heat alone? Light and heat together? A separate moving force analogous to light? Or, was light a vehicle for the moving force? Perhaps a separate Scaligerian intelligence, relocated from the planets to the Sun? And, if the Sun was a power source, then what of the planets? Were they passive recipients or themselves capable of producing their own influences, as held by traditional theoretical astrology? These questions and many others would soon form the basis of a new problematic of heavenly physics, involving the physical nature of light, the quantity of the moving power, and how it varied over distance. And again, all these new questions and conceptualizations occurred with remarkable alacrity, considering that, in 1605, not much more than a decade after the Tübingen

disputation, Kepler arrived at the elliptical orbit for Mars. How many of these new kinds of questions Kepler was asking himself as a student is harder to say.

Returning to the question of sources: Where else could Kepler search for a new sort of physical cause. In the conventional resources of academic natural philosophy? — or in unconventional ones? The specific questions that I want to address are two: whether Kepler had found such an idea of a solar moving power in Giovanni Pico della Mirandola's *Disputations against divinatory astrology* (1495) and, if so, when? These questions have been raised and explored by Louis Valcke in a recent study.[20] And his hypothesis of a link fits well with certain passages in Kepler and also with my view that Copernicus's initial proposal to reorder the planets was part of an attempt to defend the theoretical foundations of both astronomy and astrology against the massive criticisms of Pico della Mirandola.[21] Valcke calls attention, especially, to those passages in the *Disputations* where Pico claimed that the heavens act on Earth *only* by means of light and motion *rather than* through influences proper to each planet. Pico's emphasis on light was quite fundamental. Light, he said, has an "actualizing virtue": it is not itself alive but it is capable of preparing and disposing a living body for life. And, from light comes heat, as though a property — "a heat that is not fire nor even air, but rather a celestial heat ... the most efficacious and most salutary, which penetrates, warms, and orders all things".[22]

These are vivid passages, faintly resonant even with some of Newton's later descriptions of an alchemical force.[23] And it is both striking and revealing that Copernicus himself made no use of Pico's celestial heat, which is clearly indebted to the Stoically-inspired pneuma-*spiritus* of Pico's close friend, Marsilio Ficino.[24] Copernicus's hesitation in that regard underlines, once again, his cautiousness — and also Maestlin's — in moving no further than they believed to be absolutely necessary from the mathematical part of astronomy into the physical part. But, with Kepler, as we have already seen, it was different. Valcke's study shows that there are clear resonances between these passages and various texts from Kepler's Prague (1600–12) and Linz periods (1612–26). These passages all concern the similarities and differences that Kepler was trying to work out between light, heat, and the moving force.[25]

Besides Valcke's suggestive connections between Kepler and Pico, based upon scattered passages from the post-1600 period, scholars such as Mary Ellen Bowden, Judith Field, Sheila Rabin, and Anthony Grafton have by now established that Kepler was deeply engaged in what might be considered a running debate with Pico.[26] The position that Kepler sustained fairly consistently throughout these writings was that there was some truth and some falsehood in astrology and the same was true for Pico's critique of it. Kepler then took it as his assignment to separate the chaff from the wheat — or, as he put it in his still more vividly earthy way:

> No one should consider it unbelievable that out of astrological foolishness and godlessness a useful sense and holiness could [not] also be found, that in

> unclean slime could not also be scraped out a snail, mussel, oyster, or eel useful for eating, that a silk spinner could not be discovered in a big heap of caterpillar egg droppings, and finally, that a good granule from a busy hen or a peach or a gold nugget might be found in an evil-smelling dung heap.[27]

This conception of sorting out the holy from the godless, the edible from the inedible, strongly resembles the attitude that one frequently encounters in considering Kepler's selective attitude toward both planetary arrangements and planetary theories. He was not going to throw away the baby with the bath water.[28]

It is important now to ask how much of this view of Pico Kepler had worked out ten-to-fifteen years earlier in his *Tübingen* period. For if the encounter occurred only *after* he had worked out his initial ideas, then post-1599 references greatly lessen Pico's impact on Kepler's physical/astrological problematic. The *earlier* that we can place these connections, the more problems that are resolved: the initial sources of Kepler's Neoplatonic and Stoic commitments, the inspiration for the central moving power, the space of possibilities that framed his effort to construct a Copernican astrology, and the physical basis for a Copernican planetary arrangement.

The most obvious place to turn for a solution is to Michael Maestlin. First, there was his ample library and his willingness to let Kepler read his annotated books. If he did own a copy of Pico's *Disputations*, then Kepler would certainly have had access to it.[29] Apart from this kind of a connection, there is good evidence that Maestlin fully shared Pico's critique of astrology — especially Pico's attack on the reality of the zodiac.[30] On the other hand, Maestlin plainly believed that Copernicus's solution to the order of the inferior planets had answered Pico's objections to astronomers.[31]

If, however, Maestlin was the proximate source of the 1593 disputation, there is (as yet) no evidence to confirm such a hypothesis one way or another. On the other hand, if Georg Liebler was the presiding master for Kepler's performance, as I have already speculated, then one might do no better than to consult Liebler's *Epitome of natural philosophy*.[32] Liebler was a Melanchthonian with respect to astrology.[33] As such, one would expect him to have been an *opponent* of Pico. According to Liebler, astrology, like optics and music, was to be seen as a mixed discipline lying between mathematics and physics. Although Liebler as a philosopher did not concern himself with the mathematical part of astrology — casting horoscopes or writing annual forecasts — he did accept Melanchthon's view that the heavenly bodies act through physical forces on the terrestrial realm. As such, the young astrologizing Kepler might have been drawn to Liebler's position, seeking a Melanchthonian physical justification for a practice in which he wished to engage as a mathematician. Yet, as it turned out, Liebler did not oblige. Ever faithful to his Melanchthonian roots, he *also* rejected Pico's theory of celestial force![34] Most importantly, Liebler clearly stated his objection to Pico in his textbook. And I believe that this objection then became the source of a topic that Kepler disputed in

1593. Here is the passage from Liebler:

> The heaven is moved not so that it may heat but so that the stars may communicate their forces to the parts annexed to them, from one to the other, in accord with the capacity of matter to receive. I do not judge to be true what [Pico della] Mirandola contends in *Against the astrologers*, Book III: [namely] that the heavens have no particular force beyond the universal influence of motion and light; but certainly the celestial heat enlivens and stimulates these lower things to growth, while cold and dryness come about by accident. For we see that some days of winter are excessively hot and, on the other hand, some summer days are exceedingly cold. But I do not think that this could occur unless there were some specific force (*pecularias aliqua vis*) in the stars by whose qualities these lower bodies are moved. And I think that these forces (*vires*) of the stars come forth from their own particular forms....[35]

This passage is highly suggestive of important connections and theoretical positionings. A Copernicanizing and astrologizing Kepler evidently found in Liebler's rejection of Pico's light physics an occasion for a disputation in which one finds significant elements for constructing a dynamic heliocentric arrangement and a heliocentric astrology.[36] For Kepler, it was not the Scaligerian individual planetary souls and intelligences but light that initially became a physical source of planetary motion in 1593. Shortly after, in the *Mysterium*, the Scaligerian element, which I have speculated was already part of his earlier problematic, became explicit, although without publicly invoking Scaliger's authority to his contemporaries until many years later. The cause of motion had now metamorphosed into a moving soul emanating from the centrally-placed Sun — analogous to, but not identical with, light. In this slightly later formulation, the elements were three: with Scaliger, it was a soul; with Pico, it was a singular cause; with Copernicus, it was located in the Sun. In astronomy, this search for a moving virtue as efficient cause of planetary motion continued;[37] within a few years it would again be replaced, this time by a magnetic force. In astrology, however, Kepler sought to explain terrestrial effects by joining light to archetypal causes. By 1601, he regarded astrological effects as produced by the *Earth's* soul when stimulated by certain geometric/harmonic configurations of planetary light rays.[38]

In first using light as an efficient cause, Kepler thus aligned himself with just that part of Pico's conception of heavenly influence that, for quite different reasons, both his teachers had disavowed — Liebler, because he supported a traditional astrology of individual *planetary* forces; Maestlin, because he rejected *all* forms of astrology. Kepler thus forged a position between the two of them and he maintained this "centrist" stance as his ideas evolved in later writings.[39] But, in the early student disputation of 1593, where he defended Maestlin and Copernicus before the physics candidates, he had found a "gold nugget" in Pico's "dung heap".

REFERENCES

1. This paper is a fraction of a larger project whose working title is: "The Copernican question: Prognostication, scepticism and celestial order." It covers the period from Copernicus's student days in Cracow and Bologna in the 1490s and ends around 1610 with Kepler's *New astronomy* and Galileo's presentation of his telescopic discoveries. Hereafter cited as *The Copernican question*.
2. See, for example, Owen Gingerich, "Johannes Kepler and the New Astronomy", *Quarterly journal of the Royal Astronomical Society*, xiii (1972), 346–60, reprinted in Owen Gingerich, *The eye of heaven* (New York, 1993), 305–22, pp. 308–9; and, more recently, Bruce Stephenson, *Kepler's physical astronomy* (Princeton, 1994; first pub. 1987).
3. Johannes Kepler, "Fragmentum orationis de motu Terrae", *Gesammelte Werke*, xx/1, 147–9; James R. Voelkel, "The development and reception of Kepler's physical astronomy, 1593–1609", Ph.D. Dissertation, Indiana University, 1994, pp. 12–23 [a revised version is forthcoming as *The composition of the* Astronomia nova: *The context and content of Kepler's* New astronomy (Princeton, in press)].
4. E. A. Burtt, *The metaphysical foundations of modern science* (New York, 1924; 2nd rev. edn, 1932), 58–59: "the exalted position of the Sun in the new system appears as the main and sufficient reason for its adoption."
5. T. S. Kuhn, *Structure of scientific revolutions* (Chicago, 1962; 2nd edn, 1970), 152–3.
6. This is a theme with which I was concerned long ago in "Kepler's adoption of the Copernican hypothesis", Ph.D. dissertation, University of Michigan, 1971.
7. See Friedrich Paulsen, *The German universities and university study*, transl. by Frank Thilly and William Elwang (New York, 1906), 24–25. On the development of the institution of the academic disputation, see William Clark, "On the dialectical origins of the research seminar", *History of science*, xxvii (1989), 111–54, esp. pp. 115, 145.
8. See Max Caspar, *Kepler*, transl. by C. Doris Hellman with additional material by Owen Gingerich and Alain Segonds (New York, 1993), 44.
9. For Liebler, see Charlotte Methuen, *Kepler's Tübingen*: *Stimulus to a theological mathematics* (Aldershot, 1998), 193–7, 203, 221–2, 226.
10. Müller taught ethics, 1592–1626, *ibid.*, 227.
11. Johannes Kepler, *Mysterium cosmographicum*, "Preface to the Reader" (*Gesammelte Werke*, i, 9: "ut non tantùm crebrò eius placita *in physicis disputationibus candidatorum* defenderem: sed etiam accuratam disputationem de motu primo, quòd Terrae volutione accidat"; my italics).
12. Alain Segonds points out that, in his *Epitome astronomiae*, Maestlin defined efficient and final causes as foreign to astronomy: "efficientis et finalis causae tanquam ab Astronomia alienae nulla fit mentio" (cited in Johannes Kepler, *Le secret du monde*, transl. with notes by Alain Segonds (Paris, 1984), 232n.). Yet, of course, Maestlin followed the generally accepted notion that astronomy contained a mathematical and a physical part.
13. The profound impression that Scaliger made upon the young Kepler is attested by an extensive group of notes that he added to the 1621 edition of the *Mysterium*, the first one of which was affixed to the first word in the book's title, *Prodromus* (= Precursor): "When I began my studies of philosophy in 1589 at the age of 18, the *Exercitationes exotericae* of Julius C[aesar] Scaliger was found in the hands of the young. One after another, I took the opportunity offered by this book to think about a variety of things on a variety of questions, such as on the heaven, souls, demons, elements, the nature of fire, the origin of springs, the ebb and flow of the sea, the shape of the Earth's continents and the seas that separate them, etc." (*Gesammelte Werke*, viii, 15; see Segonds's further useful commentary on this passage, *op. cit.* (ref. 12), 238–9).
14. Johannes Kepler, *Epitome astronomiae copernicanae*, *Gesammelte Werke*, vii, Book iv, Part 2, 294; *Epitome of Copernican astronomy*, transl. by Charles Glenn Wallis (Great Books of the Western World, 16; Chicago, 1952; first publ., 1939), 891: "As a matter of fact, the professed Christian Scaliger and also the other followers of Aristotle dispute as to whether this motion of

the orbs is voluntary and as to whether understanding and desire are the source of the will in the movers.... Furthermore, moving souls were added, tightly bound to the orbs and informing them, in order that they might assist the intelligences somewhat; or because it seemed necessary for the first mover and the movable [body] to unite in some third thing; or because the power [to cause] motion was finite with respect to the space to be traversed and the movement was not of an infinite speed but was described in a time measured out according to space: and, by this argument, the ratio of the moving power to the movable body and to the spaces was fixed and measured." Here and elsewhere, I have modified Wallis's translation.

15. British Library: shelf no. C.61.c.6. For the Tycho-Maestlin dedication see Robert S. Westman, "The comet and the cosmos: Kepler, Mästlin and the Copernican hypothesis", in *The reception of Copernicus' heliocentric theory*, ed. by Jerzy Dobrzycki (Warsaw and Wrocław, 1972; Boston, Dordrecht, 1972), Plate 2; also Owen Gingerich and Robert S. Westman, *The Wittich Connection: Priority and conflict in late sixteenth-century cosmology*, *Transactions of the American Philosophical Society*, lxxviii, no. 7 (1988), 60.
16. Kepler, *op. cit.* (ref. 14), 294; Kepler, transl. Wallis (ref. 14), 892: "For Aristotle will readily grant that a body cannot be transported by its soul from place to place, if the orb lacks the organ which reaches out through the whole circuit to be traversed, and if there is no immobile body upon which the sphere may rest. Moreover, even if we grant solid orbs, nevertheless there are vast intervals between the orbs. Either these intervals will be filled by useless orbs which contribute nothing to the state of movement — which is most absurd; or else, if there are no solid orbs throughout these intervals, then the spheres will not touch one another or carry one another."
17. Kepler, *op. cit.* (ref. 14), 294; Kepler, transl. Wallis (ref. 14), 891.
18. Kepler's reasoning in a crucial passage of the *Mysterium* is a further evolution of the position adumbrated in the 1593 disputation (brackets refer to the notes that he added in 1621): "But if, nevertheless, we wish to get closer to the truth, and to find some regularity in the proportions, then one of two conclusions must hold: either it is necessary that [note 2] the moving souls are weaker the further they are from the Sun; or [note 3] that there is one moving soul placed at the centre of all the orbs, that is, in the Sun, which vigorously incites a body to motion the closer that it is to it; but in those bodies furthest removed, because of their remoteness and the weakening of the [moving] virtue, it becomes fainter. Therefore, just as the source of light is in the Sun and the origin of the circle is in the place of the Sun, that is in the centre, so too life, motion and the world soul belong to that same Sun...." Kepler's 1621 note to this passage confirms both that Scaliger shaped the problematic of his earlier thinking and that by the later date, he felt no constraint in publicly acknowledging his earlier adherence to Scaliger's position: "For once I believed absolutely that the cause which moves the planets was a soul, as I was of course imbued with the teachings of J. C. Scaliger on moving Intelligences. But when I reflected that this moving cause grows weaker with distance, and that the Sun's light also weakens with distance from the Sun, from that I concluded, that this force is something corporeal, if not in an exact sense then at least in an equivocal sense, that is, when we say that light is something corporeal, that is to say, a *species* that originates from a body, but which is immaterial" (Kepler, *Gesammelte Werke*, viii, chap. 20, 113; transl. Segonds (ref. 12), 137–8, 140–1; *cf.* Johannes Kepler, *Mysterium cosmographicum — The secret of the universe*, transl. by A. M. Duncan with introduction and commentary by E. J. Aiton (New York, 1981), 203).
19. As Bruce Stephenson aptly notes, "The solid-sphere models had long coexisted with mathematical astronomy. They were compatible with the geometrical models for the very direct reason that they too were geometrical models", *op. cit.* (ref. 2), 26.
20. "Jean Pic de la Mirandole et Johannes Kepler: De la mathématique à la physique", *Rinascimento*, 2nd ser., xxxvi (1996), 275–96; for his Keplerian passages, Valcke draws liberally from Gérard Simon (*Kepler, astronome-astrologue* (Paris, 1979)) and also, Sheila Rabin ("Two Renaissance views of astrology: Pico and Kepler", Ph.D. Dissertation, City University of New York, 1987).

21. Robert S. Westman, "Copernicus and the Bologna culture of prognostication, 1496–1500", chap. 2, *The Copernican question*. For a very brief, early statement of this thesis see my "Copernicus and the prognosticators: The Bologna period, 1496–1500", *Universitas*, no. 5 (December, 1993), 1–5.
22. Giovanni Pico della Mirandola, *Disputationes adverus astrologiam divinatricem* (Bologna, 1495), Book VI, chap. 4.
23. "For nature is a perpetuall circulatory worker, generating fluids out of solids, and solids out of fluids, fixed things out of volatile, & volatile out of fixed, subtile out of gross, gross out of subtile..." (quoted in B. J. T. Dobbs, *The foundations of Newton's alchemy or "The Hunting of the Greene Lyon"* (Cambridge, 1975), 206).
24. I believe that Pico's source in this passage is Ficino rather than Aristotle, as Valcke claims, *op. cit.* (ref. 20), 291n. More generally, see Peter Barker, "Stoic contributions to early modern science", *Atoms, pneuma and tranquillity: Epicurean and Stoic themes in European thought*, ed. by Margaret J. Osler (Cambridge, 1991), 135–54.
25. Valcke, *op. cit.* (ref. 20), 291–3.
26. Mary Ellen Bowden, "The Scientific Revolution in astrology: The English reformers, 1558–1686", Ph.D. Dissertation, Yale University, 1974; Judith Field, "A Lutheran astrologer: Johannes Kepler", *Archive for history of exact sciences*, xxxi (1984), 189–272; Sheila Rabin, "Kepler's attitude toward Pico and the anti-astrology polemic", *Renaissance quarterly*, l (1997), 750–70; Anthony Grafton, *Commerce with the Classics: Ancient books and Renaissance readers* (Ann Arbor, 1997), 123–5. Simon in *Kepler, astronome-astrologue* (ref. 20) wrote an extremely important account of Kepler's astrology but with surprisingly little attention to Pico.
27. Quoted and transl. in Rabin, *op. cit.* (ref. 26), 754; Johannes Kepler, *Gesammelte Werke*, iv, 161. I have slightly emended Rabin's translation.
28. This is precisely the trope that Kepler invokes in the title to his *Tertius interveniens*, a polemic with the Piconian Philip Feselius: *Third Man in the Middle, that is, a warning to certain theologians, physicians and philosophers, and especially to Philip Feselius, that in their just condemnation of the star-gazing superstition, they should not throw out the baby with the bath water and in this way unwittingly harm their profession* (*Gesammelte Werke*, iv, 147). For fuller discussion of this work, see Rabin, *op. cit.* (ref. 26), 143–98.
29. A group of books once owned by Maestlin are extant in the Stadtbibliothek Schaffhausen, including, most famously, his heavily annotated copy of Copernicus's *De revolutionibus*. Some 20% are books that Kepler sent to him and there is also a copy of Galileo's *Sidereus nuncius* with the 1633 provenance of Maestlin's son, Gottfried; but unfortunately one does not find Pico's *Disputationes* in this collection.
30. I discuss this matter in *The Copernican question*, chap. 9: "The second generation Copernicans: Maestlin and Digges." So far as I know, Richard Jarrell was the first to call attention to Maestlin's opposition to astrology, although without establishing the connection to Pico that I am arguing for ("The life and scientific work of the Tübingen astronomer Michael Maestlin, 1550–1631", Ph.D. Dissertation, University of Toronto, 1972), 138–40, 166, 176.
31. In the *Narratio prima*, Rheticus maintained that "Pico would have had no opportunity, in his eighth and ninth books, of impugning not merely astrology but also astronomy if he had known Copernicus's teachings". To this passage Maestlin affixed a reader's postil showing that he knew the full name intended: "Picus Mirandola" (Johannes Kepler, *Gesammelte Werke*, i, 94).
32. Georg Liebler, *Epitome philosophiae naturalis* (Basel, 1561, 1566, 1573, 1575, 1581, 1589).
33. See Methuen, *op. cit.* (ref. 9), 196.
34. For Melanchthon's rejection of Pico, see, *inter alia*, *Corpus Reformatorum*, ed. by C. G. Bretschneider, v (Halle, 1838; repr. New York, 1963), 819.
35. This passage occurs under the question: "Of what substance are the stars [made]?": "Mouetur autem coelum non ut calefaciat, sed ut uires suas astra cum subiectis partibus, alijs communicent pro materiae recipientis habilitate. Nec uerum esse arbitror, quod Mirandulanus libro aduersus

Astrologos tertio contendit, Coeli praeter communem luminis et motus influentiam nullam peculiarem uim esse: sed coelesti quidem calore haec inferiora uiuificari et vegetari: frigus autem et siccitatem ex accidente fieri. Videmus enim hybernos quosdam dies admodum calidos, et contrà aestiuos valde frigidos: quod fieri non posse existimo, nisi astris quibusdam peculiaris aliqua uis inesset, hisce qualitatibus inferiora haec corpora afficiendi. Vires autem illas astrorum à proprijs ipsorum formis prouenire arbitor..." (*Epitome philosophiae naturalis*, 1573 edition, 224). The identical passage appears in the 1589 edition on pp. 234–6 (see Methuen, *op. cit.* (ref. 9), 195 n. 101); it appears likely that the argument was already present in the first edition, but I have been unable to confirm it.

36. I discuss Kepler's attempt to establish heliocentric foundations for astrology in *The Copernican question*, chap. 13: "Galileo and Kepler's Copernican problematic."
37. As James Voelkel aptly puts it, "Kepler introduced motive power into his period–distance function", *op. cit.* (ref. 3), chap. 2; on light and the *virtus motrix*, see David C. Lindberg, "Kepler's theory of light: Light metaphysics from Plotnius to Kepler", *Osiris*, 2nd ser., ii (1986), 5–42, esp. pp. 38–39.
38. No later than the end of 1601, Kepler had worked out the elements of a reply to Piconian scepticism in his *De fundamentis astrologiae certioribus* (Prague, [1601]; Field, *op. cit.* (ref. 26)), although he would not take on Pico publicly until the *De stella nova* in 1606 (*Gesammelte Werke*, i, 172–97).
39. See, for example, ref. 28.