

# Kepler's Theory of Force and His Medical Sources

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## Abstract

Johannes Kepler (1571–1630) makes extensive use of souls and *spiritus* in his natural philosophy. Recent studies have highlighted their importance in his accounts of celestial generation and astrology. In this study, I would like to address two pressing issues. The first is Kepler's context. The biological side of his natural philosophy is not naively Aristotelian. Instead, he is up to date with contemporary discussions in medically flavored natural philosophy. I will examine his relationship to Melanchthon's anatomical-theological *Liber de anima* (1552) and to Jean Fernel's very popular *Physiologia* (1567), two Galenic sources with a noticeable impact on how he understands the functions of life. The other issue that will direct my article is force at a distance. Medical ideas deeply inform Kepler's theories of light and solar force (*virtus motrix*). It will become clear that they are not a hindrance even to the hardcore of his celestial physics. Instead, he makes use of soul and *spiritus* in order to develop a fully mathematized dynamics.

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## Keywords

Johannes Kepler – Philip Melanchthon – Jean Fernel – Galen – force – causality – magnetism – species – *spiritus* – spirit – innate heat – physics – cosmology – medicine – mathematics

## Introduction

In the *Astronomia nova*, Johannes Kepler offered to the brave new world a Copernican physics, wherein the Earth's motion could be explained in terms of an efficient cause issuing from the sun. His physics is not a completely new production. It is usually depicted as a multiplication-of-species theory, adapted to fit with certain elements of William Gilbert's (1544–1603) magnetic philosophy. The task of this article is to demonstrate that Kepler's force at a distance owes a debt to sixteenth-century medical theories. An emphasis on the medical side of this force will also bring out the continuity in Kepler's thinking, from his first book, the *Mysterium cosmographicum* (1596), to the *Astronomia nova* (1609), after which his celestial physics does not change significantly, although detail and depth are added. Historians have noticed the difference between these two accounts of force. In the *Mysterium*, planetary motion results from the solar soul extending throughout space. In the *Astronomia*, it results from a magnetic motive virtue (*virtus motrix*). As J.A. Bennett has written,

Kepler was influenced by Gilbert to make precisely this move from spiritual to physical forces. In the *New astronomy* the action of a soul in cosmology is relegated to the rotation of the Sun, all other motions following by magnetic action according to the principles of Keplerian physics.<sup>1</sup>

Bennett gives here what is still a mainstream interpretation, which seems corroborated by Kepler's own words. At the end of his career, he writes this about the youthful *Mysterium*: "If for the word 'soul' you substitute the word 'force', you have the very same principle on which the Celestial Physics is established in the *Commentaries on Mars*, and elaborated in Book IV of the *Epitome of Astronomy*."<sup>2</sup> But Bennett's summary is wrong on one point and vague on

1 J.A. Bennett, "Cosmology and the Magnetical Philosophy 1640–1680," *Journal for the History of Astronomy*, 12 (1981), 165–177, 166.

2 Johannes Kepler, *Gesammelte Werke* [KGW], ed. Walther von Dyck et al. (Munich, 1937–), 8: 113. Johannes Kepler, *The Secret of the Universe*, trans. A.M. Duncan (New York, 1981), 203.

another. It is wrong in saying that the solar soul is relegated to spinning the sun around; instead, the solar soul remains the source of force.<sup>3</sup> It is vague on its use of the term “spiritual force.”

The word “spirit” (*spiritus*) is usually employed by Kepler either to signify the Holy Spirit (*Spiritus Sanctus*) or to signify one of the most concrete objects in Renaissance and early seventeenth-century natural philosophy: the medical spirits that travel through the body, serving as instruments of the soul. Readers of Kepler in translation can sometimes be caught unawares by the use of the English adjective “spiritual.” Aiton, Duncan and Field, in their translation of the *Harmonices mundi*, translate *facultas animalis* as “spiritual faculty” or *idea animalis* as “spiritual idea.”<sup>4</sup> This is perfectly fine, but it is important for readers to know that Kepler is referring to animal spirits here, that is, to an essential and everyday object of Galenic medicine. Kepler is not using *spiritus* in a naïve way either. He would have been exposed to Galenic medicine during his education at Tübingen and to ‘best-selling’ sixteenth-century works of natural philosophy written by physicians. While there are several studies on Kepler’s use of soul and spirit, both in his astrology and his accounts of celestial generation, I will consider these issues in relation to his dynamics. It is here where Kepler’s use of vital principles dovetails nicely with seventeenth-century discussions on substances and their causal powers. Existing studies have also been quite internalist. Patrick Boner, for example, who has just published an excellent book on Kepler’s use of cosmological souls, does not treat Kepler’s relationship with his contemporaries on the nature of soul and spiritual instruments, nor is he interested in the lively conversations on these topics among natural philosophers.<sup>5</sup>

3 This has also been noted by Miguel A. Granada, “A Quo Moventur Planetæ?. Kepler et la question de l’agent du mouvement planétaire après la disparition des orbes solides,” *Galilaeana: Journal of Galilean Studies*, 7 (2010), 111–141, 136.

4 Johannes Kepler, *The Harmony of the World*, trans. E.J. Aiton, A.M. Duncan, and J.V. Field (Philadelphia, 1997). For ‘spiritual faculty’, see KGW, 6: 241. Kepler, *Harmony of the World*, 327. For ‘spiritual idea’, see KGW, 6: 278. Kepler, *Harmony of the World*, 374.

5 On Kepler’s use of souls in astrology and celestial generation, Patrick Boner has by far done the most work. See, for example, Patrick J. Boner, “Kepler’s Living Cosmology: Bridging the Celestial and Terrestrial Realms,” *Centaurus*, 48, no. 1 (January 1, 2006), 32–39. Patrick J. Boner, “Life in the Liquid Fields: Kepler, Tycho and Gilbert on the Nature of the Heavens and Earth,” *History of Science*, 46, no. 153 (2008), 275–297. For his recent book-length study see, Patrick J. Boner, *Kepler’s Cosmological Synthesis: Astrology, Mechanism and the Soul* (Leiden, 2013). For classic studies on Kepler’s astrology, which requires the presence of mathematical souls, see Sheila J. Rabin, “Kepler’s Attitude toward Pico and the Anti-Astrology Polemic,” *Renaissance Quarterly*, 50 (1997), 750–770, and Judith V. Field, “A Lutheran Astrologer: Johannes Kepler,” *Archive for History of Exact Sciences*, 31 (1984), 189–272.

I would like to consider Kepler's *virtus motrix* in relation to contemporary medical discussions, focusing on two of his main sources, Philip Melanchthon's *Liber de anima* (1552) and Jean Fernel's *Physiologia* (1567). In the first part of this article, I will look at how medical notions of soul, spirit and vital heat inform Kepler's early theory of solar force. In the second part, I will turn to Kepler's mature theory of solar force: the species-theory that is in place from his optical work (1603) onward. I will argue that species can be considered as 'mathematized' spirits.

### Disciplinary Considerations: Medicine and Astronomy

In the sixteenth century's university setting, astronomy was subordinate to natural philosophy, from which astronomers were expected to take their first principles.<sup>6</sup> Kepler was deeply sensitive to astronomy's low status and so felt that astronomy and physics should be unified, forming a celestial physics (*physica coelestis*), which would provide the causes for celestial movement and mathematical schemes.<sup>7</sup> To this effect, he presented himself as a 'philosophical' astronomer. Humanist medical theory gave Kepler a way to think about causes, but there is more to the story than this. Medicine had a strong social and institutional status. In the sixteenth-century context, it could serve as a hotbed of intellectual synthesis, in part because it *could* push boundaries. Its hierarchically elevated status was fixed in the structure of traditional universities, with the three professional faculties of theology, medicine and law located above the arts faculty. In other words, medical professors were higher placed on the institutional ladder than professors of natural philosophy in the faculty of arts.<sup>8</sup> Professors of medicine were usually, albeit not always, also better paid, inside

6 On astronomy and disciplinary questions in the sixteenth century, see Robert Westman, "The Astronomer's Role in the Sixteenth Century: A Preliminary Survey," *History of Science*, 18 (1980), 105–147. Michael H. Shank, "Regiomontanus on Ptolemy, Physical Orbs, and Astronomical Fictionalism: Goldsteinian Themes in the 'Defense of Theon against George of Trebizond,'" *Perspectives on Science*, 10 (2002), 179–207. Peter Barker and Bernard R. Goldstein, "Realism and Instrumentalism in Sixteenth Century Astronomy: A Reappraisal," *Perspectives on Science*, 6 (1998), 232–258. Pierre Duhem, *Sauver les apparences* (Paris, 2004).

7 His project is summed up in the full title of the *Astronomia Nova: the New Astronomy Based upon Causes, or Celestial Physics (Astronomia nova aitiologetos, seu physica coelestis)*. Johannes Kepler, *New Astronomy*, trans. William H. Donahue (Cambridge, 1992), 27.

8 See Charles B. Schmitt, "Aristotle among the Physicians," in *The Medical Renaissance of the Sixteenth Century*, ed. Andrew Wear, Robert K. French, and Iain M. Lonie (Cambridge,

the university and outside, where they could supplement their income through private practice.<sup>9</sup> In a particularly delicate moment of his young career, Kepler was advised by the councilors of Graz to go into medicine.<sup>10</sup> Although he did not heed their advice, the sixteenth century knows many cases of mathematicians working their way up to a professorship in medicine, or at least to practicing medicine. Copernicus (1473–1543), among his many duties, was private physician to his uncle Lucas Watzenrode (1447–1512), the Bishop of Varmia. Jean Fernel (c. 1497–1558), passionate for mathematics and astronomy, was led into medicine for practical reasons, as John Henry has pointed out in a recent article.<sup>11</sup> Several well-known Lutherans also come to mind, like Georg Joachim Rheticus (1514–1574), Casper Peucer (1525–1602), and Duncan Liddel (1561–1613). Outside of the university, a professor of medicine or physician of repute could count the rich and powerful among his patients. Networking must account in part for the renown and success of natural philosophical works by successful physicians like Girolamo Cardano (1501–1576), Julius Caesar Scaliger (1484–1558), John Fernel, Petrus Severinus (1540/42–1602) and William Gilbert, a diverse lot that had at least two things in common: all of them *did* count the rich and powerful among their patients and all of them, perhaps excluding Severinus, were read by Kepler.<sup>12</sup>

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1985), 1–15, at 4–5. For a more up-to-date treatment, see Paul F. Grendler, *The Universities of the Italian Renaissance* (Baltimore, 2002), 267–269.

- 9 I do not know of any study on professorial salaries in sixteenth-century Lutheran universities, but I see no reason to doubt that the pay scale was similar to that in Italy, where, as Schmitt notes, junior medical professors were usually better paid than the most senior professors of natural philosophy. Schmitt, “Aristotle,” 274, n. 26. Grendler, by contrast, has pointed out that natural philosophers in Italian universities received a high salary because of natural philosophy’s importance as a preparation for medical studies: “The first ordinary professor of natural philosophy normally received the highest nonmedical salary in the faculty of arts. The exceptional natural philosopher enjoyed a salary equal to, and occasionally higher than, the best-paid professor of medicine.” Grendler, *The Universities of the Italian Renaissance*, 268.
- 10 Nicholas Jardine, *The Birth of the History and Philosophy of Science. Kepler’s “A Defence of Tycho against Ursus” with Essays on Its Provenance and Significance* (Cambridge, 1984), 228.
- 11 Also see John Henry, “Mathematics Made No Contribution to the Public Weal: Why Jean Fernel (1497–1558) Became a Physician,” *Centaurus*, 53 (2011), 193–220.
- 12 On Severinus and his relationship to Tycho Brahe, see Jole Shackelford, “Providence, Power, and Cosmic Causality in Early Modern Astronomy: The Case of Tycho Brahe and Petrus Severinus,” in *Tycho Brahe and Prague: Crossroads of European Science*, ed. John Robert Christianson, Alena Hadravová, Petr Hadrava, and Martin Solc (Frankfurt, 2002),

Regarding the general content of medical theory, it is important to note that humanist medical writers tend to emphasize continuity between the celestial region, the terrestrial region, and the human body. This intersecting of causes was naturally attractive to somebody like Kepler, who was set on unifying the physics of sky and earth – against the Aristotelian divide between supralunar and sublunar things. The emphasis on continuity is characteristic of the physician's epistemological relationship with nature: to understand all causes of bodily sickness and health, whether those causes be near or far, terrestrial or astrological. Duncan Liddel, the Lutheran professor of ~~logic~~ <sup>"mathematics"</sup> and later of medicine, writes in the dedication of his *Ars medica* (1607) that medicine penetrates to the innermost part of nature, contemplating the primary elements and their transmutations, investigating the nature of the soul, with its forces and functions. Liddel's dedication goes on to say that medicine must make an inquiry of the natural forces in metals, minerals, stones, and gems, plumbing all the way to the wealth of the seas. It must know human custom and environment. It must observe the sidereal motions to track future changes and foresee illnesses. For Liddel, medical practice requires and encompasses all domains of knowledge: astronomy and astrology, physics and botany, geography and cosmography. Within this epistemological claim is also a causal claim: if diverse phenomena can all have their effects in the human body, general causes must exist at some level.<sup>13</sup>

*Spiritus*, which we will discuss in detail in following sections, is the sixteenth century's object of continuity *par excellence*. As an intermediary between body and soul, it is often described as straddling the divide between material and immaterial. As a carrier of vital heat, it is both quotidian and divine. Frequently compared to the element of the stars, but present everywhere, it is both sublunar and supralunar. And because it is approved of by the "master of those who know," it offers something of a loophole in his rigid division of the cosmos. In short, *spiritus* enjoys a universality allowing it to bridge spaces that are separate and ontologically distinct, a fact that is clear from the classical passages most frequently trotted out whenever Renaissance writers turn to *spiritus*. D.P. Walker, in his voluminous reading, has identified three.<sup>14</sup> One is from the *De generatione animalium*, where Aristotle holds that the vital heat in semen is

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46–69. Also see Shackelford, *Philosophical Path for Paracelsian Medicine: The Ideas, Intellectual Context and Influence of Petrus Severinus (1540/2–1602)* (Copenhagen, 2004).

13 Duncan Liddel, *Ars medica, succincte et perspicue explicata ...* (Hamburg, 1607), 3f–v.

14 D.P. Walker, "Medical Spirits and God and the Soul," in *Spiritus. IVo Colloquio Internazionale Roma, 7–9 gennaio 1983*, ed. Marta Fattori and M. Bianchi (Rome, 1984), 223–44, 225–226.

analogous to the “element of the stars.”<sup>15</sup> The second passage is from Galen's *De placitis Hippocratis et Platonis*:

If we are to declare the substance of the soul, we must say one of two things: either it is the shining and aethereal body, at which conclusion the Stoics and Aristotle must logically arrive, even if unwillingly; or that it is an incorporeal substance, and that this body is its first vehicle, through which means the soul receives communication with other bodies.<sup>16</sup>

And finally, there is the *spiritus*-passage from the *Aeneid*, where the poet writes “that heaven and earth and the watery plains ... a spirit (*spiritus*) within sustains; in all the limbs mind (*mens*) moves the mass and mingles with the mighty frame.”<sup>17</sup> To these passages, we might also add another one from the *De generatione animalium*, where Aristotle observes that a generative, celestial heat fills all the world and inheres in all things.<sup>18</sup> We also need to be aware of the strong influence of Italian Neoplatonic philosophy, with its emphasis on emanation and continuity. Marsilio Ficino (1433–1499) uses *spiritus* as a link between God and nature. His World-Soul does not act directly on matter, but relies on a World-Spirit to serve as intermediary. This World-Spirit is analogous with medical spirits: it is a “most tenuous body, as if it were now soul and not body, and now body and not soul,” and it can mingle with human spirits and provide special powers.<sup>19</sup> Fernel, who Christianizes Galen by adding Ficinian ideas, makes spirit the link between the tangible human body and the star-like ethereal body that clothes the soul; *spiritus* shares in both of these natures and can act as a suitable intermediary.<sup>20</sup> But spirits are also the most practical and ubiq-

15 Aristotle, *De generatione animalium*, trans. Jowett (Oxford, 1984), 736b29–737a6.

16 Walker, “Medical Spirits,” 225. From Galen, *Claudii Galeni Opera omnia*, ed. C.G. Kühn, 20 vols. (Leipzig, 1821–1833), 5: 643.

17 Virgil, *Aenied*, trans. H.R. Fairclough (London, 1916), 556–557 (bk. 6, ln. 724–752).

18 Aristotle, *De generatione animalium*, 762a9–762a32.

19 On its closeness to medical spirits, see Marsilio Ficino, *Three Books on Life*, ed. Carol V. Kaske and John R. Clark (Binghamton, NY, 1989), 27 and 49–51. Quote from Hiro Hirai, “Concepts of Seeds and Nature in the Work of Marsilio Ficino,” in *Marsilio Ficino: His Theology, His Philosophy, His Legacy*, ed. Michael J.B. Allen, Valery Rees, and Martin Davies (Leiden, 2002), 257–284, 275–276.

20 Hiro Hirai writes, “Wishing to reconcile the new Galen of the humanists with Christianity, Fernel called upon Ficinian Platonism.” Hiro Hirai, “The New Astral Medicine,” in *Brill's Companion to Renaissance Astrology*, ed. Brendan Dooley (Leiden, 2013), 267–286. For Fernel's adaptation of Galen, see 271–274. On Fernel's innovations and ‘conservatism’, see

uitous of Galenic objects: “it will become evident that each part of the soul depends upon some spirit as its basis, through which it resides in the body and discharges all of its duties.”<sup>21</sup> Fernel writes that anyone who does not understand the importance of spirit should take a look at basic structures of the body. The arteries, cardiac cavity and cerebral ventricles are all “empty and virtually devoid of humor, but not created so large by nature without a reason.” It follows that these structures are created for the passage of spirit, which speeds through the body much faster than humors and at death escapes unperceived.<sup>22</sup>

Finally, it is important to remark that Kepler considers medicine to be close to astronomy and physics on methodological and demonstrative grounds.<sup>23</sup> There is an important divide in Kepler’s epistemology: on the one side we have his largely *a posteriori* (inductive) arguments about physical force and material composition; on the other side we have his *a priori* (deductive), geometrical arguments about the temporal and spatial architecture of the world. Regarding his preference for geometrical arguments, Kepler is not different from his teacher Michael Maestlin (1550–1631) or from Philip Melanchthon (1497–1560) himself.<sup>24</sup> But unlike Maestlin and Melanchthon, he goes much further and constructs a geometrical metaphysics based on archetypal figures: this metaphysics claims to show the divine ideas behind the centrality of the sun and behind the distances and periods of the planets.<sup>25</sup> Such a level of certainty cannot be present in physics, where one is largely beholden to experience and to *a*

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Jean Fernel, *The “Physiologia” of Jean Fernel (1567)*, trans. John M. Forrester, with introduction by John Henry and John M. Forrester (Philadelphia, 2003), 5–8.

21 *The “Physiologia” of Jean Fernel (1567)*, 263.

22 *Ibid.*, 263–265. On the speed of the *spiritus*, see 261.

23 See Boner, *Kepler’s Cosmological Synthesis: Astrology, Mechanism and the Soul*, 41–42. See Nicholas Jardine, *The Birth of the History and Philosophy of Science*, 223–224. For a strong comparison between astronomy and medicine, both of which must begin from sensory information, see Jardine, *The Birth of the History and Philosophy of Science*, 151. Also see Adam Mosley, “The Reformation of Astronomy,” in *The Impact of the European Reformation: Princes, Clergy and People*, ed. Bridget Heal and Ole Peter Grell (Aldershot, U.K., 2008), 241.

24 For Maestlin, see Charlotte Methuen, *Kepler’s Tübingen: Stimulus to a Theological Mathematics* (Aldershot, U.K., 1998), 192–193, 196–198. For Melanchthon, it suffices to look at any of his writings on geometry, for example his *Preface to Johannes Vogelin’s Book on the Elements of Geometry* (1536), in Philip Melanchthon, *Philip Melanchthon: Orations on Philosophy and Education*, ed. Sachiko Kusukawa, trans. Christine Salazar (Cambridge, 1999), 98. Also see Jonathan Regier, “Method and the a Priori in Keplerian Metaphysics,” *Journal of Early Modern Studies*, 2 (2013), 147–162.

25 The two chief *a priori* works are the *Mysterium cosmographicum* (1596) and the *Harmonices mundi* (1619). Kepler feels that the latter is his crowning moment.



*posteriori* demonstration. Physics, like medicine, must frequently “mingle the probable with the necessary.”<sup>26</sup> In the preface to the *Astronomia Nova*, Kepler tells his reader that “this is the nature of physics, of medicine, and of all the sciences which make use of other axioms besides the most certain evidence of the eyes.”<sup>27</sup> When later, in chapter thirty-four of the *Astronomia*, he presents his conclusions about the magnetic power of the sun, he does so by saying that they are “credible” and “probable.”<sup>28</sup> (William Gilbert, whom Kepler cites in this chapter of the *Astronomia*, also uses such language when advancing his “probable assertion” that the earth turns thanks to its magnetic virtue.)<sup>29</sup> The methodological closeness between physics and medicine is not unique to Kepler’s vision of the sciences. Philip Melanchthon, in his textbook on physics, makes the same comparison in very strong terms, using medicine as an example of how reasoning in physics must take place from diverse signs and effects to causes:

The other is followed (*proceditur*) from effects and signs to causes, or from what is posterior in nature (*natura posteriora*) to presuppositions, just as a doctor judges that the body has a fever from signs, stiffness, warmth, and respiration ... Thus, physical doctrine is constructed for the greater part from experience, in which generally we are led from effects and signs to causes.<sup>30</sup>

26 KGW, 3: 19. Kepler, *New Astronomy*, 47.

27 Ibid.

28 KGW, 3: 246. Kepler, *New Astronomy*, 390. On *probabilis* in Kepler’s work, see Jardine, *The Birth of the History and Philosophy of Science*, 251–252.

29 As in *probabilis assertio*. See the title of chapter three, book six. William Gilbert, *De magnetete, magnetisque corporibus, et de magno magnetete tellure; Physiologia nova, plurimis et argumentis, et experimentis demonstrata*, Peter Short (London, 1600), 214. William Gilbert, *On the Magnet (De Magnetete)*, trans. Silvanus Phillips Thompson (New York, 1958), 214.

30 The *Initia doctrinae physicae*, in Philip Melanchthon, *Corpus Reformatorum Philippi Melanthonis Opera quae supersunt omnia* [CR], C.B. Bretschneider and H.E. Bindseil, eds., 28 vols. (Halle, 1834–52; Brunswick, 1853–60, n.d.), 13: 194. Translation from Barker and Goldstein, “Realism and Instrumentalism,” 244. Also see Dino Bellucci, *Science de la nature et réformation: la physique au service de la Réforme dans l’enseignement de Philippe Melanchthon* (Rome, 1998), 308.

### Philip Melanchthon's *Liber de anima*

Let us now look at an important source that Kepler most likely read or was taught: the *Liber de anima* of Philip Melanchthon, professor of Greek in Wittenburg and famed architect of Lutheran higher education. Melanchthon was the primary influence on the promotion of natural philosophy in sixteenth-century Lutheran universities, and his legacy can be felt in the 1580s and 90s at the University of Tübingen, where over half a century before he had been a student and up-and-coming teacher.<sup>31</sup> Although there is no hard evidence that his natural philosophical texts were still used for teaching, the evidence is good that the *Liber de anima*, which went through several printings, was present in the library of the Tübingen *Stift* when Kepler was living there.<sup>32</sup> A kind of textbook on Galenic natural philosophy, the *Liber de anima* is thoughtfully organized and written in a simple, clear style.<sup>33</sup> The preface presents natural philosophy as essential to doctrinal harmony. In particular, a natural philosophic study of the soul is needed to come to grips with the most essential point of Christian doctrine: that God joined with man. The book then opens with a general discussion of the soul, focusing on classical sources and Christian doctrine. The middle bulk of the book is an exposition on human anatomy, featuring a technical lexicon and chapters on the most important organs and features. Melanchthon ends his treatise by discussing more advanced theological issues like the rational soul, intellect and free will. He believes that the soul, to be properly understood, must be studied anatomically. It must be studied by its functional manifestations:

For certainly the powers of the soul cannot be discerned unless their locations or machines in the body of man are shown in some way. For what silliness is it when someone speaks of local motion and cannot dis-

31 On Melanchthon's influence in Tübingen, see Charlotte Methuen, *Kepler's Tübingen*, chs. 5 and 6.

32 "... the earliest university library catalogues list a large number of sixteenth-century works, and if these may be assumed to be representative of the books which were in circulation at the university in the late sixteenth century, then it would seem that both Melanchthon's own works and the texts to which he had written prefaces were still popular." Methuen, *Kepler's Tübingen*, 104. Methuen notes that "The *Liber de anima* is listed in the earliest catalogue of the *Stift's* library [*Catalogus bibliothecae stipendii theologici*, ca. 1680]." *Ibid.*, n. 170.

33 On Melanchthon's reverence for Galen see, Sachiko Kusakawa, *The Transformation of Natural Philosophy: The Case of Philip Melanchthon* (Cambridge, 1995), 84–85.

tinguish between nerves on the one hand and veins and arteries on the other?<sup>34</sup>

It turns out that spirits are, as Melanchthon describes them, “something moving,” whose productions allow us to “surmise what kind of thing the soul might be.”<sup>35</sup> The soul is, in a manner of speaking, made tangible by the motion of *spiritus*. His description of spirits is *de rigueur* for the period: they are flame-like, subtle vapors, refined from the blood in the heart.<sup>36</sup> Following Galen, he admits two varieties: vital and animal. Vital spirits are responsible for spreading vital heat to every part of the body by way of arteries.<sup>37</sup> Animal spirits are of the same type as vital spirits but they are further refined in the brain and responsible for motion and perception:

The Animal spirit is of the same category of [vital] spirits that are born in the heart. It is the part that is transmitted to the brain, where it is rendered brighter by the virtue of the brain and conforming to the temperament of the brain, and is infused into the nerves as if it were light [*lumen*], and in this way it impels them [the nerves], and triggers the actions of the senses as well as local motion.<sup>38</sup>

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- 34 In the dedication to Hieronymus Baumgartner. Philip Melanchthon, *Liber de anima recognitus ab autore Philip. Melanth.* (Wittenberg, 1552), 5r. This dedicatory letter does not appear with the *Liber de anima* in volume thirteen of the *Corpus reformatorum*. It is included in volume seven, however, along with other correspondence. CR, 7: 1125–1128. Translation in Philip Melanchthon, *Philip Melanchthon: Orations on Philosophy and Education*, 155–156.
- 35 Philip Melanchthon, *Commentarius de anima* (Wittenberg, 1540), 5v–r. Translation in Kusakawa, *The Transformation of Natural Philosophy*, 90.
- 36 “Spiritus est subtilis vapor ex sanguine coctus virtute cordis, ac incensus, ut sit velut flammula, quae in diversis membris dissimiles habet actiones. Quanquam enim unus est fons spirituum, tamen locis mutantur, et mutati dissimiles habent actiones.” *Liber de anima*, in CR, 13: 6–178. *Ibid.*, 88. Also see Dino Bellucci, *Science de la nature et Réformation*, 406–416.
- 37 “Sunt autem species duae. Spiritus vitalis est flammula ex purissimo sanguine in corde nata, calorem vitalem devehens ad coetera membra, et impertiens eis vim exercendi actiones, quas calore vitali efficiunt. Ad hunc usum supra dictum est arterias esse conditas, ut hunc spiritum in omnia membra transvehant.” CR, 13: 88.
- 38 *Ibid.*: “Spiritus animalis est ex eodem genere spirituum, qui nati sunt in corde, pars transmissa ad cerebrum, ubi virtute cerebri fit lucidior, et conveniens temperamento cerebri, et in nervos infusa velut lumen, ut eos impellat, et actiones sensuum et motum localem cieat.”

Early in the *Liber de anima*, Melanchthon asks why vital spirits, rather than another sort of material, should kindle life and motion. He answers: “because such is the working of nature, just as no cause is sought for why Sky, Sun, and Moon are thus moved. It is natural. Let us not seek out further causes.”<sup>39</sup> He probably does not mean to imply that celestial objects are moved by spirit, a theory that he never offers.<sup>40</sup> On the other hand, it is hard to imagine that a reader like Kepler did not have his attention piqued. Whatever rational soul is, whether a celestial body or incorporeal, animal spirits are its “vehicle.”<sup>41</sup> Also, both animal spirit and ethereal bodies are compared to the breath of God. D.P. Walker and Sachiko Kusukawa have pointed out the rather surprising conclusion to the *spiritus* section of the *Liber de anima*. Here, Melanchthon seems to go so far as to compare the Holy Spirit with Galenic spirits:

And [the spirits, vital and animal], by their light excel the light of the Sun and all the stars; and, what is still more marvelous, in pious men the divine spirit is mixed with these very spirits, and makes them shine more brightly with divine light, so that their knowledge of God may be clearer, their ascent to Him more resolute, and their feelings towards Him more ardent.<sup>42</sup>

Walker thinks it unlikely that Melanchthon believes the Holy Spirit to be the same as medical spirits. Yet Melanchthon is putting celestial light, spirits, and

39 Ibid. 9: “Et quanquam hic etiam interrogari potest. Quare spiritu vitali accendantur vita et motus, et non alia materia, sanguine et carne, cum tamen et hic vitalis Spiritus sit materia aut halitus ex elementis ortus? Responderi potest, quia tale est naturae opificium. Ut non est quaerenda causa ulterior, quare Coelum, Sol, Luna, sic moveantur. Sed talem videmus esse naturam, nec causas posteriores quaeramus.”

40 Melanchthon, like Luther, believed that planets and stars, composed purely of luminous aether, move solely because of God’s word. This is a point he makes in his *Initia*, not in the *Liber de anima*. See Bellucci, *Science de la nature et Réformation*, 236–247.

41 “Sin autem et de Animae substantia aliquid pronuncianum est, duorum alterum dici necesse est, aut esse eam velut substantiam lucidam et corpus aethereum, aut ipsam quidem incorpoream esse, sed tamen hoc corpus, id est, spiritum animale, vehiculum esse.” CR, 13: 10. In another section, animal spirits are compared to the breath of God, which acts as a vehicle for the divine ray. Ibid., 17: “Hic autem quaestiones aliae moventur. An una sit tantum hominis anima, videlicet spiraculum illud separabile? An vero sint distinctae animae in homine, vegetativa, sentiens et rationalis, sicut Plato, Aristoteles, et Galenus loquuntur? Ac videtur mirum, quid negotii sit illi spiraculo vehenti radio divinos, cum culina, seu parte vegetatrice.” Also see pages 466–467.

42 The translation is Walker’s, “Medical Spirits and God and the Soul,” 228. Cited by Kusukawa, *The Transformation of Natural Philosophy*, 120.

the Holy Spirit on the very same sliding scale. He is accentuating their similarity in no ambiguous terms. Even the term *Spiritus Sanctus* is meant to communicate this nearness, as Melanchthon explains. God uses our words in order to convey His truth. For example, the Son is called *Logos* (λόγος), because He is born by thought (*cogitatione*): the eternal Father, considering Himself, gives birth to His image (*imago*).<sup>43</sup> The Holy Spirit, then, has its name for a very good reason: “it is what sets in motion, as if a flame, proceeding from the will of the Father and Son, whereby the divinity attaches us to Him in his immense goodness and fills us with joy, just as the mother pours out vital spirits, supplying the infant son or daughter.”<sup>44</sup>

### *Spiritus in the *Mysterium cosmographicum**

In the *Mysterium*, Kepler offers an efficient cause for planetary movement: the sun. More precisely, he concludes that the world is filled with a soul whose seat is the sun.<sup>45</sup> This soul rotates with the solar body, drawing the planets around with it. Because the power of the soul dissipates as it extends through space, a planet turns faster when it is nearer to the sun and slower when it is farther away, a fact that allows Kepler, even at this early stage, to try relating the distance of the planet with its period. Of course, Kepler was not alone in using souls to explain celestial motion. Motive souls were popular among philosophers who disagreed with each other on many other points. It was probably the ubiquity of souls that made them attractive to thinkers who denied solid spheres, such as Tycho Brahe (1546–1601) and Francesco Patrizi (1529–1597), as well as William Gilbert and Giordano Bruno (1548–1600), both early Copernicans.<sup>46</sup> In his 1621 notes to the *Mysterium*, Kepler blames his early account of planetary motion on Julius Cesar Scaliger's doctrines of “moving

43 CR, 13: 7–8: “Vetustas graeca & latina scripsit, Filium Dei dici λόγον [logon], quia cogitatione nascitur, cum aeternus Pater sese intuens gignit imaginem suam. Cogitatione enim formari imagines in nobis quoque scimus. Et cum nostris vocabulis Deus utitur, significare hoc voluit, nasci Filium cogitatione.”

44 Ibid., 8: “Ex hac umbra utcunque cogitamus de nomine Spiritus sancti, et discimus ei hanc adpellationem in divinis literis tribui, quia sit agitator, et quasi flamma, a voluntate Patris & Filii procedens, qua divinitas immensa bonitate nos sibi copulat et nos leticia complet, sicut effundit mater vitales spiritus osculans infantem filium aut filiam. Haec vocabulorum interpretatio sobrie et pie considerata de multis magnis rebus studiosos admonet.”

45 For the importance of this assumption in Kepler's technical astronomy, see Bruce Stephenson, *Kepler's Physical Astronomy* (Princeton, 1994).

46 See, for example, Granada, “A Quo Moventur Planetae?” 112–115.

intelligences.”<sup>47</sup> For Scaliger, following Aristotle, the movement of the spheres can only be explained by intellectual capacity. Scaliger’s first orb outstrips all the others in intelligence: it discerns that it was created by God, and it acts. This understanding is also love, and the intensity of love follows from fullness of understanding. The result is that the bulk (*moles*) of the first and vast heaven is turned in gyration.<sup>48</sup> Kepler, in 1596, obviously believed any motive impulse in the celestial bodies to require intelligence, a position that he would recant in the *Astronomia nova*.<sup>49</sup> But outside of this, the actual mechanism of celestial movement in the *Mysterium* has nothing to do with Scaliger. Kepler is not putting the emphasis on self-motion. While planetary souls exist, they are only responsible for the eccentricity of planetary routes.<sup>50</sup> All the emphasis in Kepler’s setup is on the sun: it is the sun that turns the planets around. Here we get to the other important component of Kepler’s scheme. The solar soul requires a medium to transmit its power, a universal air filling the world and acting as the “vehicle” of solar “influx”.

We are now in a position to appreciate the influence of Melanchthon on the *Mysterium cosmographicum*. Melanchthon uses medical spirits to illustrate the workings of the *Spiritus Sanctus*. Kepler makes a similar move, turning to the Trinity in order to explain functions in the universe and human body. The *Mysterium* sees Kepler announcing his famous sphere analogy, in which the sphere and the spherical universe are both images (*imagines*) of God.<sup>51</sup> The sun

47 KGW, 8: 113 (author’s note no. 3).

48 “Primi orbis motricem intelligentiam, sola sui ipsius intellectione id praestare. Quod est omnium maximum principium plurimarum conclusionum. Intelligit enim se a Deo creatam, ut id agat. Quare ad eam intellectionem non solum accedit consequens amor, & consensus, verum etiam opera: ita ut moles illa Caeli gyro agitetur.” Section 359.8, Julius Caesar Scaliger, *Exotericarum exercitationum liber XV. de subtilitate, ad Hieronymum Cardanum* (Paris, 1557), 464r. For more on Scaliger and Kepler, see Robert S. Westman, *The Copernican Question: Prognostication, Skepticism, and Celestial Order* (Berkeley and Los Angeles, 2011), 319–320.

49 For example, see KGW, 3: 23. Kepler, *New Astronomy*, 52. For an in-depth discussion of Kepler’s rejection of the need for planetary intelligences to guide movement, see Granada, “A Quo Moventur Planetæ?,” 130–138.

50 If there were only this soul involved in celestial movement, all planetary paths would be concentric according to the body of the sun. However, planetary paths are eccentric. Each planet must, then, be equipped with its own soul. The planetary soul exerts its own force, causing eccentricity. KGW, 1: 77. Also see, Johannes Kepler, *Le secret du monde*, trans. Alain Segonds (Paris, 1993), 185–186.

51 “Et tria potissimum erant, quorum ego causas, cur ita, non aliter essent, pertinaciter quaerebam, Numerus, Quantitas, et Motus Orbium. Ut hoc auderem effecit illa pulchra quiescentium harmonia, Solis, fixarum et intermedij, cum Deo Patre, et Filio et S. Spiritu:

corresponds to the Father. The surface, or stellar region, corresponds to the Son. And the space in between, filled with a fine air, corresponds to the Holy Spirit. Kepler, following Melanchthon, understands the Holy Spirit to be comparable to the refined matter of celestial reaches. This air, in turn, is functionally comparable to vital spirits:

Or by what bars, what chains, what heavenly adamant, has this Earth, which with Copernicus we have completely established to be moving, been brought into its sphere? With that air, no doubt, which (fermented and mixed with vapors) all we men drink in all around the surface of the Earth, which we penetrate with our hand, with our body, but do not part or separate, though it conveys the heavenly influences right into our bodies (*cum sit influxuum coelestium in media corpora vehiculum*). For this is the heaven in which we and all worldly bodies live, move and have our being.<sup>52</sup>

In the above quote, we see that the relationship between sun and air is that between soul, or the seat of the vital faculties in the heart, or simply the heart, and the vital spirit that acts as its vehicle.<sup>53</sup> More precisely, Kepler describes the intermediate air as the vehicle of celestial *influxus*. The use of “influx” to describe a faculty or power being carried by spirit is quite at home in humanist medical texts. Fernel in his *Physiologia*, for example, writes that the animal faculty will bring about movement by flowing (*influx*) through the nerves, carried by spirit, when it is commanded by the will and mental concentration.<sup>54</sup>

Peter Barker has pointed out the Stoic factor in the above passage and discussed the background of Stoic ideas that became more and more widespread in the sixteenth century, thanks in particular to the influence of Cicero's *De natura deorum*. Barker has also pointed out the deliberate and playful reference to Saint Paul's speech before the Athenians, where Paul rejects Stoic and

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quam similitudinem ego in Cosmographia persequar amplius.” KGW, 1: 9. In the sphere, the center corresponds to the Father, the surface to the Son, and the space in between to the Holy Spirit. Just as a sphere cannot exist without each of its three components, which are separate and combined, neither can the Trinity be understood without reference to its three persons, individual and one.

52 KGW, 1: 56. Duncan, *Secret of the World*, 167.

53 One of the most impressive discussions on the three parts of the world is in the *Epitome*, Kepler's textbook of astronomy, published about twenty years after the *Mysterium*. Kepler explains the functions of the three parts of the world by a series of elaborate analogies with the body, particularly with its animal and vital faculties. See KGW, 7: 259–261.

54 *The “Physiologia” of Jean Fernel (1567)*, 494–495.

Epicurean philosophy and declares that God and only God “giveth to all life, and breath, and all things.”<sup>55</sup> Kepler is, as Barker suggests, offering a criticism of the apostle’s natural philosophy. But, in doing so, he is going further. In a Melanchthonian move, he is also suggesting that the universal air be considered as a sort of image of the Holy Spirit, and that it be considered as an instrument of forces emanating from the sun. In other words, any Stoic factor is best seen against the generic *anima-spiritus* framework of Galenic medicine. Stoic cosmology does not localize the source of *pneuma*; Galenic medicine does. Kepler needs such a localization in order to portray the sun as a universal cause. As for the exact composition of the celestial air or aether, I believe that Kepler in the *Mysterium* considers it to be the same kind of substance as our air, only much thinner and not thickened by fermentation and terrestrial exhalations. There is an argument to be had that, from his optical works on, he considers aether to be a different substance from air.<sup>56</sup> This interpretation is convincing, particularly in light of book one (1618) of the *Epitome astronomiae copernicanae* (1618–1621), where he suggests that air and aether can be understood as different kinds of matter.<sup>57</sup> However, on the very same page he also stresses their similarity. He writes that both are fluid and transparent but that they differ from one another by manifest and perceptible degrees of transparency (*gradibus pelluciditatis*).<sup>58</sup>

Even as *spiritus* allows Kepler a causal template, Neoplatonic inspiration abounds, although I am not sure it would be possible to point to an exact source early in Kepler’s career. Ficino writes of air: “For indeed air and its quality sound – a less powerful thing – passes right away through solid things and influences

55 For Paul at the Areopagus, see Acts 17:22–34. Peter Barker, “Jean Pena (1528–58) and Stoic Physics in the Sixteenth Century,” *The Southern Journal of Philosophy*, 23 (1985), 93–107, 102. Also see Peter Barker, “Stoic Contributions to Early Modern Science,” in *Atoms, Pneuma, and Tranquillity: Epicurean and Stoic Themes in European Thought*, ed. Margaret J. Osler (Cambridge, 1991), 135–154, 148–149. As Kepler writes in a 1621 note to the passage we have been studying: “Ludere placuit in voce aeris paulo audacius.” KGW, 8: 94. As Barker writes, “The adverb ‘little’ (*paulo*) is a pun on the name Paul, so the passage might also be read, “It pleased me to make an audacious Pauline play with the word ‘air.’” *Ibid.*, 149, n. 44.

56 See Adam J. Mosley, “Heaven and Earth in the Late-Sixteenth Century: Tycho and Kepler on the Sub- and Supra-Lunary,” in *Nouveau ciel, nouvelle terre*, ed. Miguel Ángel Granada and Édouard Mehl (Paris, 2009), 143–154, 145–146. Also see Boner, *Kepler’s Cosmological Synthesis*, 95.

57 KGW, 7: 53: “In tertia causa discrimen hoc est, quod Aer ratione suae propriae materiae pro densitatis modulo, colorem etiam obtinet coeruleum: aether non plus coloris obtinet cum in sua propria materia consideratur, quam densitatis.”

58 *Ibid.*: “Quo discrimine sunt inter se Aether et Aer? Uterque fluidus est, uterque pellucidus; uterque pro diversitate locorum et temporum puritatis variabilis: differunt tamen manifestis et sensibilibus gradibus pelluciditatis.”



them with a quality of its own.”<sup>59</sup> Although Ficino’s air should not be confused with his *spiritus*, which conveys heavenly influences, the case is different for Cornelius Agrippa (1486–1535). Agrippa collapses air and *spiritus* into one and the same thing.<sup>60</sup> The resulting description of air in the *De occulta philosophia* (1531/33) is tantalizingly close to what we find in the *Mysterium*. Agrippa writes that air is a “vital spirit, passing through all beings, giving life, and subsistence to all things, binding, moving, and filling all things.” Agrippa goes on to describe air as “the spirit of the world’s instrument (*instrumentum*)”, writing that it “immediately receives into itself the influences (*influxus*) of all celestial bodies, and then communicates them to the other Elements, as also to all mixed bodies,” including humans and animals.<sup>61</sup>

**Vital Heat in the Optical Works: the *Ad Vitellionem Paralipomena, quibus astronomiae pars optica traditur* of 1604**

Comparisons between the heart and the heavens are common in the Renaissance and the early modern period. Pico della Mirandola writes that just as all animal motion depends on the heart, all motion in the world depends upon the first motion of the heavens.<sup>62</sup> Melanchthon echoes this same sentiment in his preface to Sacrobosco’s *De sphaera*: “Just as in our bodies life, or the first motion that resides in the heart, stimulates motion in the other members, so, since

59 Ficino, *Three Books on Life*, 323.

60 For the relationship between Ficino and Agrippa, see Vittoria Perrone Compagni, “Dispersa Intentio: Alchemy, Magic and Scepticism in Agrippa,” *Early Science and Medicine*, 5 (2000), 160–177, particularly 161–162.

61 “Superest de aëre dicere. Hic spiritus est vitalis, cuncta permeans entia, omnibus vitam et consistentiam praebens, ligans, movens et implens omnia. Hinc Hebraeorum doctores illum non inter elementa numerant, sed velut medium et glutinum diversa insimul coniungens et tanquam spiritum mundani instrumenti reboantem habent. Ipse enim proxime coelestium omnium influxus in se concipit aliisque cum elementis tum mixtis singulis communicat; non minus etiam rerum omnium cum naturalium, tum artificialium et sermonum quorumcunque species, velut deificum quoddam speculum, in se suscipit et retinet illasque secum ferens, corpora hominum et animalium per poros ingrediens, tam in somno quam in vigilia illis imprimens, variorum mirabilium somniorum, praesagiorum et auspicio-  
rum materiam praebet.” Cornelius Agrippa, *De Occulta Philosophia Libri Tres*, ed. V. Perrone Compagni (Leiden, 1992), 96. Translation in Henry Cornelius Agrippa of Nettesheim, *Three Books of Occult Philosophy*, ed. Donald Tyson, trans. James Freake (St. Paul, MN, 1993), 17.

62 Giovanni Pico della Mirandola, *Disputationes Adversus Astrologiam Divinatricem*, ed. Eugenio Garin (Florence, 1946), 399. Bk. 3, ch. 4. See 194-196 of Garin’s edition.

without doubt the motion of the heavens is the first, it rouses the other bodies to effect each their own motions.”<sup>63</sup> The sun can easily be envisioned as heart-like: it is the world’s fountain of vital heat and luminous spirit. Comparisons between sun and heart are likewise frequent, cropping up in Ficino, Bruno, Galileo (1564–1642), and Harvey (1578–1657), among others.<sup>64</sup> In the first book of Copernican astronomy ever written, the *Narratio prima* (1541), Georg Joachim Rheticus (1514–1574) notes that the heart does not race between head and foot but remains in one place and “fulfills its function through other organs designed by God for that purpose.” Likewise, the sun, emperor of nature, need not scurry between one end of his kingdom and the other, like Ptolemy had him do.<sup>65</sup> Kepler takes up the sun-as-heart analogy in his earliest extant cosmological text, a student disputation dating from 1593, and he uses it until the end of his career.<sup>66</sup> In the *Ad Vitellionem Paralipomena* (1604), he seems to want to reverse-engineer the heart in order to make it more sun-like. To explain how the heart can produce vital spirits, he posits that inside the heart is an actual flame. The description he gives of the heart is that of a sooty furnace, with the blood acting as an “oil,” the lungs as bellows, and the arteries serving as an escape for sooty material and for refined vital spirits.<sup>67</sup> In his theory of the heart, Kepler cites Jean Fernel, praising Fernel for suggesting that in the heart, there is the likeness of an enduring flame.<sup>68</sup> Kepler is probably referring to the very popular *Physiologia*, where Fernel writes:

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- 63 Melanchthon, *Philip Melanchthon: Orations on Philosophy and Education*, 109.
- 64 For Ficino, see Berthold Hub, “Gazes and Flying Images in Ficino & Michelangelo”, in *Spirits Unseen: The Representation of Subtle Bodies in Early Modern European Culture*, ed. Christine Göttler and Wolfgang Neuber (Leiden, 2008), 93–120, 104. For Bruno and Galileo, see Wilbur Applebaum and Renzo Baldasso, “Galileo and Kepler on the Sun as Planetary Mover,” in *Largo Campo Di Filosofare: Eurosymposium Galileo 2001*, ed. Jose Montesinos and Carlos Solis (Las Palmas, 2001), 381–390, 385–386. For a different opinion on Galileo’s sun see, John Henry, “Galileo and the Scientific Revolution: The Importance of His Kinematics,” *Galilaeana*, 8 (2011), 3–36, 13–14. For Harvey, see *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus ...* (Frankfurt: Guilielmus Fitzerus, 1628), 3–4.
- 65 Nicholas Copernicus and Georg Joachim Rheticus, *Three Copernican Treatises*, trans. Edward Rosen (Mineola, New York, 1959), 139. Kepler references these lines in a student disputation from 1593. See below.
- 66 In the 1593 student disputation, Kepler heaps praise on the sun, calling it, among other things, “the king of planets as regards motion, the heart of the world in strength, and the eye with regard to beauty ...” KGW, 20.1: 148. Translation from James R. Voelkel, *The Composition of Kepler’s Astronomia Nova* (Princeton, 2001), 28.
- 67 KGW, 2: 34–36.
- 68 KGW, 2: 35.

But the heart blazes with great heat, like a flame, and so cannot be maintained sufficiently by arterial pulsation, but was in need of some larger implement, such as a fan; of this sort are lungs in the animals that thrive with plenty of blood and heat, and gills in fishes.<sup>69</sup>

Fernel is also quick to make a comparison between vital heat and the solar body: “[the sun] acts as leader and ruler and regulator of the world, sheds its light over all living things, warms them equally by the temperament of its heat, and rouses them to the functions I mentioned.”<sup>70</sup> These functions include the very motive ones of nutrition, growth and perception.

There are other similarities as well between Kepler and Fernel. For example, both refer to the heat as creative (*artifex* in the *Paralipomena*; *opifex* in the *Universa medicina*).<sup>71</sup> Both stress the importance of fatty material in producing heat. Both consider plants to possess heat. For all the similarities in their accounts, there is also a crucial difference. Sixteenth-century discussions tend to follow Aristotle in distinguishing between elemental heat and the celestial heat of *pneuma*. Elemental heat, the everyday heat of a fire, is destructive. Nothing is ever born from it. Quite the contrary is true of vital or celestial heat (carried by *spiritus*), which maintains life and is produced both inside living bodies and by way of the heavens. Fernel follows this distinction between fire and innate heat.<sup>72</sup> Unlike elemental fire, both innate heat and its carrier *spiritus* are divine, where ‘divine’ means corresponding to the element of the stars.<sup>73</sup> Driving home the difference between vital and terrestrial heat, he uses an experience readily at hand to anybody who has ever walked in the woods. He notes that while all living things possess vital heat, some are cold, particularly cold plants like poppy and mandrake: “And in the temperament of the plants that I mentioned, the heat is lowered and is less than the cold. Thus cold cannot prevail here by its power and effects, and the functions of life cannot be related to it as to an efficient cause.”<sup>74</sup> Vital heat must therefore be present even when elemental heat is absent. Kepler takes an opposing position. There is only one sort of heat, the everyday heat that issues from fires or from any source of light.

69 *The “Physiologia” of Jean Fernel (1567)*, 513.

70 *Ibid.*, 259.

71 KGW, 2: 35: “in esse in corde flammam artificem.” *The “Physiologia” of Jean Fernel (1567)*, 278–279.

72 Hiro Hirai, *Medical Humanism and Natural Philosophy: Renaissance Debates on Matter, Life and the Soul* (Leiden, 2011), 70–71.

73 *Ibid.*, 71–72.

74 *The “Physiologia” of Jean Fernel (1567)*, 259.

Even the vital heat in plants results from a small fire.<sup>75</sup> Nor is heat generative in and of itself. Kepler defends the following proposition about light, of which heat is a property: "Light destroys and burns things ... it strives to make the things acted upon similar to itself, in the manner of all agents. Therefore, attacking the matter, in which the essence of all things consists, it destroys it."<sup>76</sup> The equivalence between fire and celestial heat makes sense for a Copernican, who can no longer bear a division between terrestrial and celestial matter.

Kepler's theory of light and heat does not for all that become less vital. Quite the contrary: he makes all light and heat necessarily the product of some soul. That is, all light and heat must originally issue from a soul, whether the soul of an animal, plant, planet or, most preeminently, the sun. He asks natural philosophers where they have seen a flame that did not come from an animate faculty or from something produced by an animate faculty. Dead wood burns in the fireplace because it was once alive. Oils, sulfur and coal can burn steadily because they were produced by the soul of the earth. "In fact, light is always conjoined to the animate faculty, so much so that the foremost among the physicians compare the source of life in the heart of an animal to a flame."<sup>77</sup> The sun, Kepler explains, is the densest body in the universe, and it is conjoined with the most powerful of animal souls:

Therefore, it is consistent that from the indwelling of this soul or faculty in the densest and purest body, and from its most powerful vivifying or formative faculties – that is, from the victory of the soul and the subjugation of extremely contumacious matter – light should result [...]<sup>78</sup>

### *Species as a Mathematized Spiritus*

In the *Paralipomena*, all light becomes an immaterial species (*species immaterialiata*) and heat becomes its immaterial property. In the *Astronomia nova* (1609), Kepler gives his first published account of the solar force as an immaterial species too, a magnetic one.<sup>79</sup> The outline of the set-up is easy to describe: the sun

<sup>75</sup> KGW, 2: 36. Johannes Kepler, *Optics: Paralipomena to Witelo, & Optical Part of Astronomy* [*Optics*], trans. William H. Donahue (Sante Fe, 2000), 40.

<sup>76</sup> KGW, 2: 37. Kepler, *Optics*, 41.

<sup>77</sup> KGW, 2: 200. Kepler, *Optics*, 239.

<sup>78</sup> KGW, 2: 199. Kepler, *Optics*, 239.

<sup>79</sup> Kepler had been entertaining this idea at least as early as a letter to David Fabricius in 1602. KGW, 14: 279 (letter no. 226, sent from Prague). Translation from Voelkel, *The Com-*

is a magnetic body rotating on its axis, sending out its magnetic species. The species continue to rotate along with the body of sun and, in this way, cause the planets to rotate as well. Kepler owes something to Gilbert here, but not a great deal. What Kepler takes from Gilbert's *De magnete* (1600) is the notion that the earth has an animate magnetic virtue and that this virtue can be demonstrated to be immaterial (for it cannot be blocked).<sup>80</sup> In terms of theory about what the force actually is and how it works, Gilbert is parsimonious. The mere presence of a magnetic body, like lodestone, brings about a formal awakening in a recipient object, such as iron. The strength of the bond is based on how pure the two objects are, that is, how infused they are with the earth's material body and formal soul.<sup>81</sup> Gilbert does not give a multiplication of species model as such, but his account can be easily adapted to one.<sup>82</sup> Typically, as in Roger Bacon, species are defined as an influence flowing from one body to another, causing the second body to become more like the first. Their action is formal: they activate within the recipient matter its predisposition to be like the agent of change.<sup>83</sup> For Bacon, as for his sources al-Kindi and Robert Grosseteste, light was taken as the 'paradigm case' of species.<sup>84</sup> In a sense, species theory is optics turned into universal physics; it allows for physical causes that are geometrical, that spread and change according to lines and angles.<sup>85</sup> This is an obvious draw

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position, 179. On an overview of the history of species theories, see Leen Spruit, *Species Intelligibilis: From Perception to Knowledge*, 2 vols. (Leiden, 1994–1995).

- 80 For magnetic virtue as cosmological, see William Gilbert, *De magnete*, 65. The Thompson translation of *De magnete* follows the pagination of the Latin first edition. For the soul of the earth and its magnetic virtue, see *ibid.*, 209–210. For the immateriality of magnetic virtue, see *ibid.*, 77. For an overview of Gilbert's physics, theory of earth and Copernican motives, see Gad Freudenthal, "Theory of Matter and Cosmology in William Gilbert's *De Magnete*," *Isis*, 74 (1983), 22–37.
- 81 Gilbert, *On the Magnet*, 65–71.
- 82 John L. Heilbron has written about the proximity of Gilbert's magnetic virtue to multiplication of species schemes. John L. Heilbron, *Electricity in the 17th and 18th Centuries: A Study of Early Modern Physics* (Berkeley and Los Angeles, 1979), 172.
- 83 Roger Bacon's *Philosophy of Nature: A Critical Edition with English Translation, Introduction and Notes*, of "*De Multiplicatione Specierum*" and "*De Speculis Comburentibus*," trans. David C. Lindberg (New York, 1983), lix.
- 84 This is Lindberg's useful expression, in "The Genesis of Kepler's Theory of Light," 10.
- 85 Two classic studies on the history of vision and optics are David C. Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago, 1976), and Gérard Simon, *Archéologie de la vision: l'optique, le corps, la peinture* (Paris, 2003). Both begin with the Greeks and end with Kepler and Descartes. Both take ibn Al-Haytham as the key innovator in between. On species, see David C. Lindberg, "The Genesis of Kepler's Theory of Light: Light Metaphysics from Plotinus to Kepler," *Osiris*, 2, 2nd series (1986), 5–42, and Isabelle Pantin, "Simu-

for Kepler. Species can also serve to connect diverse spaces, as spirits do. In scholastic accounts of perception and cognition, intelligible species pass through the senses and act as the bridge between outer world and mental impressions. As Isabelle Pantin puts it nicely, “when [species] were conducted through the dark corridors of the nerves to the various chambers of the brain, they adopted another form of behavior, similar to that of the spiritus which wandered among the humors.”<sup>86</sup> Species also show up frequently in humanist medicine. Fernel and Fracastoro both use the term. Fernel identifies species with “form” and seems to swap the terms indiscriminately.<sup>87</sup> Fracastoro makes species the primary cause in his theory of contagion.<sup>88</sup>

Kepler’s species, including the *virtus motrix*, are emanations from an ensouled body.<sup>89</sup> They transmit power from a source body to a recipient, allowing the source body to modify the recipient, making the recipient more like the source. The clearest case is light, which Kepler also takes to be the paradigm case of species. Light illuminates and heats bodies, rendering them more light-like even to the point of destroying them. While Kepler is always quick to remind his readers that light and *virtus motrix* (solar force) are not actually material, he also talks about them as if they were quasi-material, sharing in material’s mathematical property of extension: he refers to light as a surface, and to *virtus motrix* as a body, when he wishes to insist that they “participate in quantity.”<sup>90</sup> In his *Paralipomena*, Kepler writes that light has two aspects, “that of essence, by virtue of which it is light, and that of the quantities which it acquires.”<sup>91</sup> These quantities are exactly those acquired by interacting with material sur-

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lachrum, Species, Forma, Imago: What Was Transported by Light into the Camera Obscura? Divergent Conceptions of Realism Revealed by Lexical Ambiguities at the Beginning of the Seventeenth Century,” *Early Science and Medicine*, 13 (2008), 245–269.

86 Isabelle Pantin, “Fracastoro’s De Contagione and Medieval Reflection on ‘Action at a Distance’: Old and New Trends in Renaissance Discourse on the Plague,” in *Imagining Contagion in Early Modern Europe*, ed. Claire L. Carline (London, 2005), 3–15, 6.

87 *The “Physiologia” of Jean Fernel (1567)*, 12.

88 For Fracastoro’s species, see Andreas Blank, “Julius Caesar Scaliger on Corpuscles and the Vacuum,” *Perspectives on Science*, 16 (2008), 137–159. Leen Spruit, *Species Intelligibilis*, 2: 46–49. Also see, Pantin, “Fracastoro’s De Contagione.”

89 For a very clear explanation of this point, see KGW, 7: 298–299. Johannes Kepler, *Epitome of Copernican Astronomy & Harmonies of the World*, trans. Charles Glenn Wallis (Amherst, New York, 1995), 56–57.

90 Kepler uses “body” (*corpus*) in two distinct senses, both of which were current: in the sense of 1) a material body (*corporea materia*), and 2) that which participates in the quantity of bodies.

91 KGW, 2: 24. Kepler, *Optics*, 25.

faces, that is, the “local motions” (*motus localis*) of reflection and refraction.<sup>92</sup> As for *virtus motrix*, it is not a surface, because it seizes an entire object, through and through. He refers to it then as “corporeal.” It participates in the material quantities of bodies that receive it, namely mass (*moles*) and volume:

... the bodies of things that are moved suggest that this moving power be considered as if a sort of geometrical body, because their whole masses terminate or receive this emission of the motive *species* so that the *species* can exist or subsist nowhere in the world but in the bodies of the mobile things themselves. And, exactly like light, between the source and the movable thing it is in a state of becoming, rather than of being.<sup>93</sup>

Another way in which light and *virtus motrix* participate in quantity is that they thin out from sun to planet. They participate, then, in the quantity of space or distance. Yet they are not scattered as material objects. Rather, there is exactly as much of them in a small space as there is in a larger space, which is why Kepler is confident that there is a clean relationship between planetary distance and speed – a presupposition that is behind what we call his second and third laws. Their immateriality is, for the mathematizing physicist, a tremendous boon. In both the *Astronomia Nova* and the *Epitome*, Kepler insists that “nothing perishes in the journey from its source, nothing is scattered between the source and the illuminable or movable thing.”<sup>94</sup> In interim space, the species are in a

92 KGW, 2: 24. Johannes Kepler, *Optics*, 25–26. Kepler is refuting Aristotle, for whom light is a change in the medium and not a local movement. This also puts him at odds with Bacon, whose theory of species involves consecutive changes in a medium, brought on by contact. See *Roger Bacon's Philosophy of Nature*, lx–lxi.

93 “... ita corpora rerum movendarum efficere videntur, ut virtus haec motrix consideretur quasi quoddam corpus Geometricum, quia corpulentia tota sua terminant seu recipiunt hunc speciei motricis defluxum: ut illa nuspiam in toto mundo esse aut subsistere possit, nisi in ipsis corporibus mobilium: nec sit, sed quasi fuerit in intermedio inter fontem et mobile, plane et lux.” KGW, 3: 240. Kepler, *New Astronomy*, 382.

94 Sheila Rabin argues that by 1609, both light and *virtus motrix* have become material. She concedes that they are still immaterial in the *Astronomia nova*, because Kepler writes that “nothing of this power is lost in travelling from its source, nothing is scattered between the source and the movable body.” (S.J. Rabin, “Was Kepler's ‘Species Immateriala’ Substantial?,” *Journal for the History of Astronomy*, 36 (2005), 49–56.) However, Kepler gives the very same precision in almost the same words in the *Epitome*. It is reasonable to read Kepler as being consistent: at no point in his career is the attenuation of the *virtus motrix* due to what we might call material ‘scattering’ or ‘dispersion’. Compare the two passages below. The first is from the *Astronomia Nova*, chapter 33. The second is from the *Epitome*, 4/2: (1) “Denique cum tantundem virtutis sit in amplo et remotiori circulo, quan-

“state of becoming,” literally an “intermediate state” (*in intermedio*).<sup>95</sup> What this means is that they are realized within the material quantities of those objects with which they interact. Time is one of these temporal quantities. Species are a-temporal in and of themselves: they inhabit all bodies in their path at once.<sup>96</sup> Yet the motions that they effect in matter are temporal, like the heating and blanching caused by light: “For even if, with its accompanying heat, light is present in a moment, nevertheless, matter, by the fact that it is matter, is subject to time. Therefore, heat, now materialized and passive, can only be generated in time.”<sup>97</sup> To sum up, the species straddle the immaterial and material in such a way that they can be at once physically causal and mathematically easy-to-use.

The similarities between *spiritus* and species are not unintentional. Kepler says as much himself in the *Harmonices mundi* (1619), comparing the sun to the heart and light to its *spiritus*:

For it seems that (if there is some such world soul) it resides in the center of the world, which for me is the Sun, and from there it is propagated over the length and breadth of it by the agency of the rays of light, which are equivalent to spirits in the animate body. [Although Kepler feigns impartiality, he goes on to strongly suggest that the Sun is indeed the soul of the world. The final part of the *Harmonices* includes a paean to this soul.]<sup>98</sup>

Kepler believes that both the sun and heart produce rays outward from a central point. The soul, Kepler tells us, “has actually acquired the nature of a point (at least for the purposes of binding it to its body).” From this point it emanates along straight lines – “how would it have any other manner of coming out, exist-

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tum in angustiori et propinquo; nihil igitur perit de hac virtute in itinere ex fonte suo, nihil inter fontem et mobile dispersum est.” KGW, 3: 240. Kepler, *New Astronomy*, 381. (2) [Here Kepler is comparing light and the *virtus motrix*]: “... utriusque descensus de luminoso corpore, fit in momento, utraque transit medium magnum et parvum sine jactura, non vectigalis, nihil perit in itinere ex fonte suo, nihil inter fontem et illuminabile vel mobile dispergitur.” KGW, 7: 304. Kepler, *Epitome of Copernican Astronomy*, 62–63.

95 See below. *Radiationes* is here synonymous with *species*.

96 “Motions, of which sounds are a disposition, are considered as Becoming, insofar as they take time; radiations more as instantaneous Being. For just as a body exists at this moment, so also a radiation exists at this moment; whereas of motion what has passed no longer is, what follows is not yet, in a moment it is nothing.” KGW, 6: 245. Kepler, *Harmony of the World*, 333.

97 KGW, 2: 36. Kepler, *Optics*, 41.

98 KGW, 6: 265. Kepler, *Harmony of the World*, 359.



ing as light and flame, than other lights coming out of their sources, that is, on straight lines?"<sup>99</sup> By the outward emanation of *spiritus*, the soul not only controls the body, it also senses. We should not confuse the vital faculty's power of sensing with vision. They are not the same thing. In plants, animals and the soul of the earth, the former is responsible for perceiving astrological influences and is more primordial than vision. This explains how a baby, just at the moment when its vital faculty is lit by a first rush of air from the lungs, can be affected by planetary positions. The planetary positions are literally stamped on the animal spirits flowing from the freshly lit heart.<sup>100</sup> As for ocular vision – this is performed by what Kepler calls "visual spirits," which carry impressions of retinal images. As Kepler stresses, "the impression itself is not optical, but physical and mysterious."<sup>101</sup> We see here that Kepler does retain a strictly physiological kind of spirit. It is fully material, or at least more material than light.

The fact that species derive their power from the quantity of matter present in a source body should not be lost on us. In the *Epitome*, Kepler's textbook on celestial physics and astronomy, he provides his most systematic treatment of immaterial species. He begins by insisting that we make a rational distinction between a species and the power or force which it carries.<sup>102</sup> In Neoplatonic optics, there is a traditional distinction established by Plotinus between *lux*, the material light of a source, and *lumen*, the immaterial emanation of the source light. According to David Lindberg, Kepler does not hold to this distinction and uses the two synonymously.<sup>103</sup> While this may be true in his optical works, Kepler actually does use the distinction when discussing the nature of *species immateriatae* in the *Epitome*. Here, *lux* is firmly embodied. It is the fire of the sun's extremely dense matter. Its species, *lumen*, is immaterial and carries illumination and heat.<sup>104</sup> Kepler makes this distinction between species and embodied power because he wishes to emphasize that a force is never "without a proportional subject" (*sine subjecto analogo*), where the subject is matter. The subject of solar light and *virtus motrix* is thus the sun's body itself.<sup>105</sup> Here

99 KGW, 6: 275. Kepler, *Harmony of the World*, 371.

100 KGW, 6: 278. Kepler, *Harmony of the World*, 374.

101 For example, see KGW, 2: 151–153. Kepler, *Optics*, 180–181.

102 In the *Epitome*, Kepler seems to use power (*virtus*) and force (*vis*) as synonyms.

103 Lindberg, "The Genesis of Kepler's Theory of Light," 34.

104 "Non est dubium quin sicut Sol totus est luminosus, sic sit etiam totus ignitus, et propter materiae densitatem, omninò candenti massae auri, aut si quid densius, comparandus. Iam ex luce illa Solis egreditur et ad nos delabitur species non corporea, non materiata, quam lumen vel radios Solis dicimus, quae tamen quantitates et accidentia recipit..." KGW, 7: 303.

105 KGW, 7: 302–303. Kepler, *Epitome of Copernican Astronomy*, 60–61.

Kepler is talking about a relationship between the strength of a power and some quantifiable aspect of the body from which it originates. The power of the *species immateriae* must be related, at the source, to an embodied faculty. In the case of light, Kepler clearly holds the sun's heating power to be related to the sun's great density and heft (not just to its powerful pyric soul).<sup>106</sup> The *virtus motrix* is also related to the amount and density of matter present. Earlier in the *Astronomia nova*, Kepler had relied on the identification of magnetism with *virtus motrix* to make this exact point. The magnetic power resides "in the entire body of the magnet"; following Gilbert's results, the power grows or diminishes with the magnet's quantity of matter. "So in the sun the moving power appears so much stronger that it seems likely that its body is of all [those in the world] the most dense."<sup>107</sup> To conclude, the strength of this embodied *virtus motrix* is reliant on a quantity of matter and volume, not just the power of the soul.

The way in which a planet responds to the *virtus motrix* is also linked to its own mass, volume and distance from the sun. In Kepler's mind, this is why his harmonic law holds. It is important to remember, as several commentators have remarked, that Kepler does not consider his third law universal in anything like our sense. It would not work given any universe. Rather, it only works because God has carefully calibrated distances, masses and volumes. As for why the mass of the sun is as it is, or why the mass of any other planet is as it is, the harmonic law serves as a kind of master proportion arising from several simpler proportions linking masses, volumes and distances.<sup>108</sup> Yet for these proportions to come together and express themselves in activity they need a physical intermediary that is in itself without matter: the *virtus motrix*. In other words, Kepler requires the *virtus motrix* to transmit quantified power in a regular way over distance. Not surprisingly, this quantified power diminishes in a perfect, inverse linear relationship with distance, meaning that it propagates as a circle, just as light propagates as a sphere whose intensity is inverse to the surface area of the

106 On the Sun's density as fairly close to that of gold, see KGW, 7: 284. On the amount of matter packed into the Sun as being a third of that of the universe, see KGW, 7: 287–288. On the density of the Sun related to its emanation of light and heat, see KGW, 7: 298.

107 Here Kepler is talking about the Sun's magnetic power in comparison with the Earth's, which causes the moon's orbit. KGW, 3: 245. Kepler, *New Astronomy*, 390.

108 "Of these, the length of the orbital path (proportional to the mean distance  $r$ ) and the strength of the solar force (inversely proportional to  $r$ ) would by themselves combine to give the relation described in the *Astronomia nova*. The other two factors are the mass of the planet, which on the basis of archetypal reasons he took to be proportional to  $\sqrt{r}$ , and the volume (measuring the ability of the planet to assimilate the solar force), which on the basis of observational evidence he felt he could take proportional to  $r$ ." Kepler, *Harmony of the World*, 411–412, n. 46.

sphere (hence  $1/r^2$ ).<sup>109</sup> It is also, as I have noted above, this perfectly inverse linear relation of *virtus motrix* to distance that in Kepler's mind provides the physical foundation of his second law.

Clearly, sixteenth century and many seventeenth century natural philosophers do not adhere to what we call Cartesian dualism.<sup>110</sup> Instead, they think in terms of gradations: certain things are more refined or coarse than others. Such thinking is possible in a hylomorphic framework, because matter can be dominated in varying degrees by form. As we have just seen, Kepler's species-forces look a great deal like *spiritus*. Their ultimate reliance on the soul of the sun makes them active and formal; meanwhile, their reliance on the body allows them to transmit bodily quantities. They can be physical, even corporeal in a geometrical sense, and yet immaterial. An interesting result of their mixed-status is that they can relate bodily quantities without modifying those quantities in transit. They are like reified proportions. While Kepler's theory of immaterial species was not long-lasting, his conception of force as mathematical reification strikes me as deeply suggestive. A proportion relating bodily quantities is, after all, how all forces are described in classical and contemporary physics. Newton's wish in the *Principia* to refrain from speculation about the nature of gravity, which cannot be described mechanically, is an affair meant to protect not only his reputation but also the mathematical architecture of his system. For Kepler, who could not be hounded by unborn mechanists, there was no such problem. He had a physical, mathematical and universal physics that was a study in life.

109 On the circular diffusion of *virtus motrix*, see, for example, KGW, 3: 240. For Kepler's statement of the inverse square law in optics, see Proposition 9 of his *Ad Vitellionem Paralipomena*, in KGW, 2: 22. Kepler does not have the concept of inertia found in classical physics. He is still 'Aristotelian' on this count. For him, all motion must be caused by a force, even constant motion. The speed of a planet is thus a direct indication of the solar force's strength. Planetary speed does indeed change more or less linearly in relation to distance.

110 As Justin Smith has recently noted, strict Cartesian mechanism was probably never predominant in the seventeenth century. Justin E.H. Smith, "Spirit as Intermediary in Post-Cartesian Natural Philosophy," in *Spirits Unseen: The Representation of Subtle Bodies in Early Modern European Culture*, ed. Christine Göttler and Wolfgang Neuber (Leiden, 2008), 269–291, 271.