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The place of Edward Gresham's *Astrostereon* (1603) in the discussion on cosmology and the Bible in the early modern period

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Abstract. This article situates Edward Gresham's *Astrostereon, or A Discourse of the Falling of the Planet* (1603), a little-known English astronomical treatise, in the context of the cosmo-theological debate on the reconciliation of heliocentrism with the Bible, triggered by the publication of Nicholas Copernicus's *De revolutionibus orbium coelestium* in 1543. Covering the period from the appearance of the 'First Account' of Copernican views presented in Georg Joachim Rheticus's *Narratio Prima* (1540) to the composition of *Astrostereon* in 1603, this paper places Edward Gresham's commentary and exegesis against the background of the views expressed by his countrymen and the thinkers associated with the Wittenberg University – such as Philipp Melanchthon, Caspar Peucer, and Christoph Rothmann. Comparing the ways in which they employed certain biblical passages – either in favour of or against the Earth's mobility – the paper emphasizes Gresham's ingenious reading of the Hebrew version of the problematic excerpts, and his expansion of the accommodation principle.

Edward Gresham (1565–1613) – a mathematician, astrologer and notorious 'rotten engine' in the early Jacobean English landscape – is an obscure figure of seventeenth-century London.[1] Little is known of his life. He came from Stainford, Yorkshire, and studied at Trinity College, Cambridge (matriculating as a sizar in 1584), where he probably received his MA by 1606.[2] Gresham practised astrology in London and lived in upper Thames Street, next to Dyers Hall, until his death. He is mainly recognized as the author of astrological almanacs and prognostications for the years 1603–7, and the editor of *Strange feareful & true newes* … (London, 1606). He also figures in two

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1 Compare Arthur Wilson, *History of Great Britain, Being the Life and Reign of King James the First* …, London: Printed for Richard Lownds, 1653, p. 70.

2 Compare John Venn, *Alumni Cantabrigienses*, 2 parts, Cambridge: Cambridge University Press, 1922, part i, vol. 2, p. 264; and Bernard Capp's entry for 'Edward Gresham' in *ODNB* (23 September 2004).

major scandals of the early reign of King James I: his prognostication for 1605 – now lost – allegedly foretells the Gunpowder Plot, and he plays a part in the so-called Overbury affair. Both earned him his later reputation of a Papist traitor and a conjuror involved in devilish practices.[3] As Mark Dawson suggests, in his lifetime Gresham was a reputed astrologer, commended for his prognostications, whose clients belonged to various social strata, and included the victims of petty criminals.[4] At the same time, in his letters, Gresham admits that 'some friends' encouraged him to start writing almanacs and prognostications (for which he was often scolded by others), though it drove him away from 'greater studies'.[5] As it seems, Gresham's intellectual ambitions were much higher.

Following a now classic analysis by Francis R. Johnson, in his overview of the reception of Copernicanism in Great Britain, John L. Russell identified Gresham as an eager supporter of the heliocentric system.[6] Both historians quote Gresham's preface from his 1607 prognostication, where he defends himself against accusations of atheism and heresy:

> And some (I heare) who (for that I am *paradoxall* in many things, but especially in the frame and *systeme* of the world, differing from all Phylosophers and Diuines in that poynt, as they thinke) absolutely condemne me of *Atheisme* and *Haeresie*. To these I reply, that *Apostasie* from *Errour* to *Truth*, is no good *Argument* of *Atheisme* … But if these inconsiderate *Paralogists*, had euer seen my *Sabboth-dayes* exercises for these many yeeres continuance, (in farre better sort bestowed then the world did imagine) or my *Positions in Diuinitie*, (both extant vnder my hand) or my *Astrostereon*, (a booke I wrote in the hart and heat of the last great Visitation, wherein with a reuerend reconciliation of the Word, with these scrupulous *Paradoxes*, I haue neither done iniury to God nor Nature) they would (without doubt) haue been better opinionate of mee.[7]

According to Gresham, his accusers deem him atheist and heretic because he differs from the authorities in his view of the 'frame and *systeme* of the world'. As Gresham implies, these critics had not seen his other works, in which those paradoxes are reconciled with Scripture. But on what grounds did they make these accusations? His opponents might have been referring to Gresham's prognostication for 1606, in which he explicitly wrote

3 Compare 'Cecil Papers: January 1605, 16–31', in M.S. Giuseppi (ed.), *Calendar of the Cecil Papers in Hatfield House*, vol. 17: *1605*, London, 1938, pp. 15–43. *British History Online*, at http://british-history.ac.uk/cal-cecil-papers/vol17/pp15-43 (accessed 21 December 2016); Michael Sparke, *The Narrative History of King James for the First Fourteen Years. In Four Parts*, London: Printed for Michael Sparke, 1651, pp. 20–1, 43; anon., *Observations upon the Strange & Wonderful Prophecies …*, London: Printed for J.H., 1680, p. 1.

4 Mark Dawson, 'Astrology and human variation in early modern England', *Historical Journal* (2013) 56, pp. 31–53, esp. 31–2.

5 Edward Gresham, *A new Almanack and Prognostication for the Yeere of our Lord God 1607*, London: Imprinted at London for the Company of the Stationers, 1607, sig. B2r.

6 Compare Francis R. Johnson, *Astronomical Thought in Renaissance England: A Study of the English Scientific Writings from 1500–1645*, Baltimore: Johns Hopkins University Press, 1937, pp. 249–50; John L. Russell, 'The Copernican system in Great Britain', in Jerzy Dobrzycki (ed.), *The Reception of Copernicus' Heliocentric Theory*, Wrocław: Ossolineum, 1972, pp. 189–239, 213; Antonia McLean, *Humanism and the Rise of Science in Tudor England*, London: Heinemann, 1972, p. 128; Keith Thomas, *Religion and the Decline of Magic*, London: Penguin Books, 1991 (first published 1971), p. 416.

7 Gresham, op. cit. (5), sig. B2v, italics in the original.

about the Earth circling the Sun: 'Our Orbe (as any other) obliquely circling the globouse body of light, is variablie affected with light and darknesse, and in utmost limits with greatest difference'.[8]

Of the other texts mentioned by Gresham, it seems that only *Astrostereon* (1603) is extant (in five manuscript copies, three in the British Library in London, and two in the Bodleian Library in Oxford).[9] The treatise was written at a time of plague in London in 1603 in order to refute claims that a planet would fall and thus determine the consequences of the epidemic. Allegedly, this rumour was started by Gresham and John Dee (1527–1608/9), though there are no extant printed sources (if there ever were) to prove it.[10] Gresham wanted to defend his reputation and tried to convince the people who might have believed the hearsay – both of the 'vulgar' and 'better sort' – that due to the real frame of the world, such an event could never occur.[11] Although the text was never printed in Gresham's lifetime, the layout of the copy dated 1610 (BL Sloane MS 3936) indicates that it might have functioned as a scribal publication, or that it was prepared with a printing publication in mind. The most prosaic reason why Gresham never published *Astrostereon* could be lack of money and patronage. Nearly a hundred years after its creation, fragments of the treatise (with changes) were published in instalments in John Gadbury's *Ephemeris* for the years 1700–5, reflecting the astrologer's fascination with Gresham's work.[12] Gadbury's copy of *Astrostereon* is listed in Edward Bernard's *Catalogue of English Libraries* (1697), with a note that the things discussed in *Astrostereon*, such as the influence of the solar light and heat on the planets, 'at that time were very rare'.[13] Gadbury appreciated Gresham already in his *Collectio Geniturarum* (1662), in which he calls him 'the most ingenious person and good Artist', endowed with 'sharp active Fancie'.[14] In his *Ephemeris*, he calls Gresham a 'Learned author'.[15] Gadbury's high opinion of Gresham's skills stands in sharp contrast with widespread views of him expressed in seventeenth-century texts.

But what is interesting here is that a person who, in his time, was primarily perceived as an almanac maker, an astrologer–physician and, eventually, a wrongdoer – a person

8 Edward Gresham, *A new Almanack and Prognostication for the Yeere of our Lord God 1606*, London: [s.n.], 1606, sig. B7v.

9 BL: Sloane MS 3936, Sloane MS 753, Sloane MS 3279; BLO: Ashmole MS 192 (II), Ashmole MS 1807 (I).

10 Compare Glyn Parry, *The Arch-conjuror of England: John Dee*, New Haven, CT: Yale University Press, 2013, p. 265.

11 Edward Gresham, *Astrostereon, or A Discourse of the Falling of the Planet*, British Library, Sloane MS 3936, ff. 3r–45v, fol. 4v. All further quotations from *Astrostereon* come from this copy. For the convenience of reading, all the contractions and special signs have been expanded. Otherwise the original variants of spelling have been kept (including the references to the books in the Bible). Some missing letters have been put in square brackets. Italics have been retained. Original punctuation has been preserved whenever possible.

12 John Gadbury, *Ephemeris: or, A Diary Astrological, Astronomical, Meteorological for the Year of our Lord 1700*, London: Printed by J.R. for the Company of Stationers, 1700 (and for the following years).

13 Edward Bernard, *Catalogi Librorum Manuscriptorum Angliae et Hiberniae in Unum Collecti, cum Indice Alphabetico*, 2 vols., Oxford: Sheldonian Theatre, 1697, vol. 2, p. 221.

14 John Gadbury, *Collectio Geniturarum: or, A Collection of Nativities*, London: Printed by James Cottrel, 1662, pp. 179–80.

15 John Gadbury, *Ephemeris: or, A Diary Astrological, Astronomical, Meteorological for the Year of our Lord 1701*, London: Printed by J.R. for the Company of Stationers, 1700, title page.

of whom there are no easily retrievable records proving his engagement in any of the national or international intellectual networks (such as that of William Gilbert, for example, or the Royal College of Physicians) – presented in his treatise an extensive view of Copernican astronomy grounded in natural philosophy, which certainly goes beyond purely hypothetical considerations. Although *Astrostereon* was known to twentieth-century researchers, until recently it has not received extensive critical attention.[16] To name just a few instances of Gresham's remarkable insights contained within this text: he is the first person in the history of astronomy to have predicted the occultations of stars by planets using the Copernican theory; he also rejected the existence of solid celestial spheres, promulgating the free movement of planets in space.[17] As Jarosław Włodarczyk has recently proposed, Gresham's naked-eye observations of the Moon might have prompted Thomas Harriot's (*c.*1560–1621) first telescopic lunar observation of 26 July 1609.[18] Furthermore, Gresham's attempts to reconcile heliocentrism with Scripture – apart from being heavily influenced by the Calvinist interpretations (see below) – also include a unique perspective on Hebrew biblical etymologies. In a semi-Neoplatonic, semi-Paracelsian vein, Gresham further develops his views, assuring his readers that a heliocentric and – more importantly – a heliostatic system is entirely compliant with the Bible.

Although the third generation of Copernicans turned towards the natural-philosophical implications of heliocentrism – which would partially explain Gresham's approach – there were few stronger supporters of the validity of the Copernican model in the pre-telescopic era. Similarly, it would be difficult to find an ordinary practitioner openly promulgating such views then. The discrepancy between Gresham's popular image and his philosophical and mathematical inclinations is precisely the reason why such hitherto neglected figures of the English intellectual landscape should be reconsidered and their works thoroughly investigated.[19] Such an analysis may help us better grasp the fluctuation of trends, practices and needs which characterized intellectual debate at the turn of the seventeenth century.

Gresham's Copernicanism in context

We must remember that 'Copernicanism' was not a monolith term.[20] Even that 'handful' of most devout supporters of Copernicus's thought cannot be considered a

16 See Bernard Capp, *Astrology and the Popular Press: English Almanacs 1500–1800*, London: Faber and Faber, 2008 (first published 1979), p. 191; and Thomas, op. cit. (6), p. 389 n. 22.

17 J. Włodarczyk, R.L. Kremer and H.C. Hughes, 'Edward Gresham, Copernican cosmology, and planetary occultations in pre-telescopic astronomy', *Journal for the History of Astronomy* (2018) 49(3), pp. 269–305, 270.

18 Jarosław Włodarczyk, 'The pre-telescopic observations of the Moon in early seventeenth-century London: the case of Edward Gresham (1565–1613)', *Notes and Records* (2020) 74, pp. 35–53, 49, at https://doi.org/10.1098/rsnr.2019.0009.

19 Compare Christopher Hill, *Intellectual Origins of the English Revolution Revisited*, Oxford: Clarendon Press, 2012 (first published 1997), p. 47 n. 170.

20 Compare Robert Westman, *The Copernican Question*, Berkeley, Los Angeles and London: University of California Press, 2011, p. 309.

homogeneous group.[21] Robert Westman's shortlist comprises – apart from Rheticus, Kepler, Galileo, Harriot and Stevin – a Jesuit 'biblical commentator', Diego de Zuñiga; a 'gentleman–harbour engineer', Thomas Digges; a 'court mechanician' and astronomer, Christoph Rothmann; a 'professor of astronomy and mathematical subjects', Michael Maestlin; and a 'peripatetic natural philosopher', Giordano Bruno.[22] Their social and intellectual backgrounds, as well as their religious denominations, determined the way they first approached and later developed and appropriated Copernicus's ideas. Katherine Tredwell and Peter Barker supplemented Westman's list with Gemma Frisius and William Gilbert, showing that new names could still be added.[23] Gresham is such a case, though his persona (or at least previous depictions of it) seems rather modest in comparison with the main protagonists. At the same time, Gresham appears to be well acquainted and preoccupied with some of the themes which were raised in the crucial debates on the nature of the universe, such as the physical qualities of celestial bodies, or the astronomical implications for astrology.[24] Gresham's vested interest in the restoration of true astrology based on solid foundations in mathematical astronomy seems understandable, but what were the intellectual influences that can explain the mathematical and cosmological development of his astronomical thought?

Gresham's contemporary, Thomas Bretnor (1570/1–1618), who is often called 'the most advanced Copernican among the almanac-makers', was friendly with Edmund Gunter (1581–1626), the third Gresham Professor of Astronomy, which could partially explain Bretnor's mathematical interests.[25] We lack such direct links for Gresham, although, in *Astrostereon*, he mentions the 'learned friends' who dissuaded him from publishing his more scholarly works (such as the treatise on the better use of prognostications) for a vulgar audience.[26] But he never gives the names of these friends, nor indicates his influences.

Jarosław Włodarczyk has recently suggested that Gresham might have been familiar with Gilbert's map of the Moon (eventually published posthumously in *De Mundo Nostri Philosophia Nova* in 1651, but created *c.*1600).[27] As mentioned above, Gresham's observations from *Astrostereon* might in turn have influenced Thomas Harriot. However, these links – as any other of such type – are not attested in any known written records, documents or correspondence. Similar ambiguity surrounds other prominent figures with whom Gresham is sometimes associated, such as John Dee (see above) and Simon Forman (1552–1611). Forman is listed along with Gresham and other popular astrologers in Ben Jonson's play *The Devil Is an Ass* (Act I, scene ii):

21 Compare Westman, op. cit. (20), p. 309; and Katherine Tredwell and Peter Barker, 'Copernicus' first friends: physical Copernicanism from 1543 to 1610', *Filozofski vestnik* (2004) 25(2), pp. 143–66, 143–4.

22 Compare Westman, op. cit. (20), p. 309.

23 Compare Tredwell and Barker, op. cit. (21), pp. 144.

24 Compare Westman, op. cit. (20), esp. pp. 245–6, 310, 320–3.

25 Compare Hill, op. cit. (19), p. 46; and Johnson, op. cit. (6), p. 252.

26 Gresham, op. cit. (11), fol. 38r.

27 Włodarczyk, op. cit. (18), 47.

> I, they doe, now, name *Bretnor*, as before
> They talk'd of *Gresham*, and of *Doctor Fore-man*,
> *Francklin*, and *Fiske*, and *Sauory* (he was in too).[28]

As the Overbury trial testimonies indicate, Gresham replaced Forman as the conjuror in service to Frances Howard.[29] Whether Gresham knew Forman in person is uncertain, but a 'Master Gressam' appears in Forman's papers over a decade earlier, as someone to whom astrological and astronomical books, stolen from Forman's house at Lambeth in March 1598, were offered for sale by three Cambridge students. Forman's friend, George Coney, received this information from 'Master Napier' (either Richard or Robert), who indeed might have been one of Gresham's acquaintances.[30]

A direct documented connection can be made only between Gresham and 'Savory', i.e. Abraham Savery (fl. 1604–33) of Westminster, who was a gentleman and, like Gresham, lived in Thames Street. He was an actor and an impostor–physician who was also involved in the Overbury case, though he was eventually cleared of all charges. As Mark Eccles has found, on 7 September 1611 Savery (Savorie) gave bail for Edward Gresham, 'his fellow astrologer and conjuror, to answer charges at the next gaol delivery'.[31]

These loose threads do not allow us to draw any reliable conclusions as to whether there was someone in particular who helped Gresham to form his unorthodox views. It was most probably a combination of various factors – his immediate influences, readings, university training and mathematical practice. We do know, however, how Gresham chose to defend those views – just like his opponents, he referred to the authority of Scripture.

As we have seen in the letter to the Reader quoted above, Gresham was aware that what he believed to be the real system of the world, for the majority of both simple and educated people, remained a paradox.[32] 'Paradoxes' were claims against common opinion, and at the time common opinion followed the geocentric model of the universe, which theologians and some philosophers supported with the relevant excerpts from the Bible. The most often quoted passages were Psalms 104:5, Psalms 93:1, Psalms 19:6, Joshua 10:12–14, and Ecclesiastes 1:4–6.[33] Those who practised Lutheran literalism in reading Scripture could not allow heliocentrism to be any more than hypothesis. However, in the light of new mathematical and empirical evidence, the supporters of

28 Ben Jonson, *The Devill Is an Ass*, in *The Works of Ben Jonson: Bartholomew Fair. The Devil Is an Ass. The Staple of News. The New Inn. The Magnetic Lady*, vol. 6 (ed. Charles Hereford and Percy Simpson), Oxford: Clarendon Press, 1966, p. 169.

29 Compare Fulke Greville and Arthur Wilson, *The Five Yeares of King Iames, or, The Condition of the State of England, and the Relation it Had to Other Provinces*, London: Printer for R.W., 1643, p. 19.

30 Compare Lauren Kassell, *Medicine and Magic in Elizabethan London*, Oxford: Clarendon Press, 2005, pp. 29–30.

31 Mark Eccles, 'Elizabethan actors IV: S to end', *Notes and Queries* (1993) 40(2), pp. 165–76, 166.

32 See Barbara Bienias, 'Edward Gresham's *Astrostereon, or A Discourse of the Falling of the Planet* (1603), the Copernican paradox, and the construction of early modern proto-scientific discourse', *Studies in History and Philosophy of Science Part A* (2020) 82, pp. 44–56, esp. 46, 52.

33 See Barbara Bieńkowska, 'The heliocentric controversy in European culture', in Bieńkowska (ed.), *The Scientific World of Copernicus*, Dordrecht: D. Reidel Publishing Company, 1973, pp. 119–32, esp. 119–20.

heliocentrism often referred to the so-called 'accommodation principle' which, in Peter Harrison's words, 'was an elaboration of a long-standing hermeneutical principle *Scriptura humane loquitur* – Scripture speaks in human language' – so that it could be understood by everyone.[34] Therefore, in the development of the studies in natural philosophy conducted in parallel to those of Protestant theology, there were two approaches in reading the Bible – literal and exegetical. These two strategies were being used in order to solve one of the biggest epistemic conflicts in the Protestant Reformation period – the conflict between truth and appearance.

Pointing to the consequences of the independent reading of the Holy Writ, Peter Harrison has claimed that

> Protestant insistence on the primacy of scriptural authority demanded a new approach to the interpretation of scripture, and that this hermeneutical stance brought with it an alternative conception of the natural order – a conception which was the precondition for the emergence of natural science.[35]

For early modern thinkers, seeking the correspondence between the Word of God and natural philosophy was not easy, especially as they all carried the burden of their confession and ecclesiastical exegesis of the Bible. Therefore the task of those scholars who were leaning towards the Copernican system and who were faced with these theological predicaments was to aver that there was no discrepancy between God's two books – Scripture and Nature.[36] Consequently, those who favoured the Copernican system felt prompted to prove that there was no clear evidence in the Bible to contradict the fact of the Earth's mobility.

In *Astrostereon*, Gresham uses the authority of Scripture in relation to cosmology on numerous occasions (most prominently in Chapters 1.8, 1.9, 2.2 and 3.3), starting with a Latin motto from Job 38:37 – 'Quis enarrabit Caelorum rationem, aut concentrum Caeli quis dormire faciet' – which he places on the title page.[37] Gresham's voice in the discussion on Copernicanism and the Bible is unique, as he uses Hebrew etymologies to demonstrate that Scripture does not contradict the movement of the Earth. What is more, he employs arguments from the Bible to support the idea of the free movement of planets in space. In order to appreciate the complexity of Gresham's viewpoint, we must first take a closer look at how the discussion of Copernican theory and the Bible was shaped both in Elizabethan England and in the most prominent circle of Protestant scholars associated with Wittenberg University.

34 Peter Harrison, *The Bible, Protestantism and the Rise of Natural Science*, Cambridge: Cambridge University Press, 1998, p. 133. See also Stephen Snobelen, '"In the language of men": the hermeneutics of accommodation in the Scientific Revolution', in Jitse M. van der Meer and Scott H. Mandelbrote (eds.), *Nature and Scripture in the Abrahamic Religions: Up to 1700*, 2 vols., Leiden: Brill, 2008, vol. 1, pp. 691–732.

35 Harrison, op. cit. (34), p. 107.

36 See Kenneth Howell, *God's Two Books: Copernican Cosmology and Biblical Interpretation in Early Modern Science*, Notre Dame, IN: University of Notre Dame Press, 2002.

37 'Who can declare the order of the heavens, or who can make the harmony of the heaven to sleep?' I use the Douay–Rheims Bible (DRA) for all translated quotations from the Vulgate, and the Tolle Lege Press edition of the 1599 Geneva Bible (GNV) for those from Hebrew.

The early reception of Copernicus in England

Although John L. Russell has proposed that Copernican theory in England 'began to earn popularity' after the publication of William Gilbert's *De Magnete* (1600), the early reception of Copernicus in England started much earlier.[38] It was initiated by Robert Recorde's *The Castle of Knowledge* (1556), by John Field's *Ephemerides* (1556, 1558) based on Reinhold's Copernican tables, and most explicitly by Thomas Digges's *A Perfit Description of the Coelestiall Orbes …* (1576), which was reprinted at least seven times before 1605, accompanying his father's *A Prognostication euerlasting*.[39] Recorde discusses heliocentrism only briefly, in a dialogue between the Master and the Scholar.[40] Having praised Copernicus's learning, experience and 'diligence in observation', the Master concludes that a discussion of the 'renewed opinion of Aristarchus Samius' requires a deeper knowledge, and as such is out of place in an introductory context.[41] Field's *Ephemeris Anni 1557* was published at London in 1556 with a preface by John Dee acclaiming Copernicus's mathematical skill. Although Dee leans towards the Copernican system, he never fully confirms his support.[42] It was Thomas Digges who had no doubt that the Copernican theory was more probable than geocentrism, as it reflected the true image of the world.[43]

Digges (*c.*1546–95) had already promised to prove Copernicus's theory in his *Alae seu Scalae Mathematicae* (Mathematical Wings or Ladders) in 1573, a work prompted by the appearance of the nova in 1572, and written in order to improve the parallactic method devised by Regiomontanus through the enhancement of observational methods.[44] But it was in the *Perfit Description* that Digges wanted to present 'demonstrative knowledge', a 'new Theorick' supported by empirical proofs.[45] Although Robert Westman calls Digges 'a Platonist who never left his comfortable chair', Digges's augmented translation and edition of the fragments from Book I of *De revolutionibus* helped to popularize Copernican ideas in England.[46] Antonia McLean has suggested that, after Digges's publication, in university circles Copernican thought was

38 Compare Russell, op. cit. (6), p. 211.

39 McLean, op. cit. (6), p. 147.

40 Robert Recorde, *The Castle of Knowledge*, London: Imprinted by Reginalde Wolfe, 1556, pp. 164–5. For English proto-Copernicans see Pietro D. Omodeo, *Copernicus in the Cultural Debates of the Renaissance*, Leiden: Brill, 2014, pp. 37–40; and Francis R. Johnson, 'The influence of Thomas Digges on the progress of modern astronomy in sixteenth-century England', *Osiris* (1936) 1, pp. 390–410.

41 Recorde, op. cit. (40), p. 165.

42 See Peter J. French, *John Dee: The World of the Elizabethan Magus*, New York: Routledge, 2013 (first published 1987), pp. 97–103.

43 Thomas Digges, *A Perfit Description of the Coelestiall Orbes …*, London: Imprinted by Felix Kyngston, 1605 (first published 1576), sig. M1v.

44 Compare Dana Jalobeanu, 'A natural history of the heavens: Francis Bacon's anti-Copernicanism', in Wolfgang Neuber, Thomas Rahn and Claus Zittel (eds.), *The Making of Copernicus: Early Modern Transformations of the Scientist and His Science*, Leiden: Brill, 2014, pp. 65–87, 75–7. See also Stephen A. Johnston, 'Making mathematical practice: gentlemen, practitioners and artisans in Elizabethan England', unpublished PhD dissertation, University of Cambridge, 1994, pp. 77–83.

45 Compare Westman, op. cit. (20), p. 274.

46 Westman, op. cit. (20), p. 279.

widely known and appreciated even if not unanimously accepted.[47] Copernicus's theory was presented alongside (and often compared to) Ptolemy's.[48]

Universities at Oxford and Cambridge went through curriculum reforms in the 1560s–70s which eventually led to establishing new lectureships in mathematics by the mid-1580s.[49] As John S. Mebane has argued, the advancement of learning in England in the 1580s was a response to new social and economic perspectives after the return of Sir Francis Drake's ship from a bountiful voyage around the world, and an ambition to match Spanish 'wealth and power'.[50] Technological change was simply geopolitically expedient. Thus new astronomical or mathematical theories could be discussed in search of the best solutions to, for example, problems in navigation, gunnery or engineering.[51] The intensity and pragmatics of London mathematical practice from the 1580s to the 1590s have been thoroughly studied in relation to the urgent need to equip English seamen and military men with the necessary skills and instruments to face potential new threats from Spain, and to gain an advantage in the world of increasing geographical discoveries and colonial endeavours.[52]

Various mathematical skills and improved scientific instruments were also needed on a local scale. Apart from the possibilities laid out by the scholars at London's Gresham College (founded in 1597), other merchant-inspired activities, such as Sir Thomas Smith's appointment of Thomas Hood (1556–1620), a mathematician, to give public lectures in London (1588–92), could have influenced many mathematical practitioners, sometimes of lesser prominence or pedigree, who often, in the privacy of their households, explored the secrets of nature and experimented with instruments produced on the spot.[53]

However, as S.F. Mason rightly observed, such practical factors as 'economic drive' could explain the growth in such fields as 'magnetism, mechanics, and astronomy, but not the structure and the pattern of the new theories, such as the heliocentric system

47 McLean, op. cit. (6), p. 147. See also W.P.D. Wightman, *Science and the Renaissance*, Edinburgh: University of Aberdeen Press, 1962, vol. 1, pp. 116–17.

48 Mordechai Feingold, *The Mathematicians' Apprenticeship: Science, Universities and Society in England, 1560–1640*, Cambridge: Cambridge University Press, 1984, p. 13. See also Hill, op. cit. (19), p. 20 n. 22.

49 Compare Feingold, op. cit. (48), pp. 39–42.

50 John S. Mebane, *Renaissance Magic and the Return of the Golden Age: The Occult Tradition and Marlowe, Jonson, and Shakespeare*, Lincoln and London: University of Nebraska Press, 1992 (first published 1989), p. 73.

51 Compare David W. Waters, *The Art of Navigation in England and Early Stuart Times*, New Haven, CT: Yale University Press, 1958; Hill, op. cit. (19), p. 61; and Katherine Hill, '"Juglers or Schollers?": negotiating the role of a mathematical practitioner', *BJHS* (1998) 31, pp. 253–74, 256.

52 See Stephen Johnston, 'Mathematical practitioners and instruments in Elizabethan England', *Annals of Science* (1991) 48(4), pp. 319–44, doi: 10.1080/00033799100200321; and Lesley B. Cormack, 'Mathematics for sale: Mathematical practitioners, instrument makers, and communities of scholars in sixteenth-century London', in L.B. Cormack, S.A. Walton and John A. Schuster (eds.) *Mathematical Practitioners and the Transformation of Natural Knowledge in Early Modern Europe*, Dordrecht: Springer, 2017, pp. 69–85.

53 Compare Chapter 15 in L.B. Wright's *Middle-Class Culture in Elizabethan England*, Chapel Hill: University of North Carolina Press, 1935; and Deborah Harkness's *The Jewel House: Elizabethan London and the Scientific Revolution*, New Haven, CT and London: Yale University Press, 2007.

of the world, or the theory of the circulation of blood'.[54] For Mason, the development of such notions – especially in England – was influenced by theology, and Calvinism in particular.[55] What is more, in England, there was no institutionalized opposition to new theories (unlike, for example, the resistance of the Catholic Church in continental Europe which led to the appearance of *De revolutionibus* on the Index of Prohibited Books in 1616).[56]

It does not mean, however, that such an opposition based on religious arguments did not exist. Biblical citations were deployed by natural philosophers opposed to the heliocentric system because it contradicted both Scripture and the principles of Aristotelian physics. In his analysis of Bible usage in the English astronomical treatises in the Renaissance, Paul Kocher found,

> By about 1600 … arguments from the Bible were being so widely applied against the new astronomy that its proponents could no longer continue to turn their heads the other way. As examples of this tendency may be cited two able popular treatises written at this time, Thomas Blundeville's *Excercises* (1597) and Thomas Hill's *The School of Skil* (1599), both of which discuss the Copernican theory but reject it for scientific and religious reasons alike.[57]

Indeed, although Blundeville (*c.*1522–*c.*1606) – whose *Exercises* were in fact first published in 1594 – reveres Copernicus's intellectual prowess, he considers his heliocentric theory a mathematical supposition – a false supposition used only to make 'truer demonstration' of physical phenomena.[58] As proof of the Earth's immobility, he evokes the authority of Ptolemy and Aristotle, followed up by two passages from Psalm 104.[59] Similarly, Hill (*c.*1528–75) states that 'both holy scriptures confirme, and Phisicke reasons prooue', that Copernican theory cannot be accepted.[60] He then proceeds to quote (without giving the numbers of verses) Psalms 104:5, Ecclesiastes 1:5 and Psalms 104:2.[61]

We must remember that Hill and Blundeville were skilful translators and compilers of works from the Continent.[62] They successfully popularized, rather than tested, the ideas. From their point of view, the Copernican world system was only a hypothesis or a supposition – as it was presented in the unauthorized Osiander's Letter to the Reader (*Ad Lectorem*) printed with the first edition of *De revolutionibus* – as a mathematically useful tool.[63] Since it was only a hypothesis, or an old paradox of the Pythagoreans, the attempts at reconciling the theory with Scripture were often limited to quoting the

54 S.F. Mason, 'Science and religion in 17th-century England', *Past and Present* (1953) 3, pp. 28–44, 28.

55 Mason, op. cit. (54), p. 28.

56 Compare Paul Kocher, 'Use of the Bible in English astronomical treatises during the Renaissance', *Huntington Library Quarterly* (1946) 9(2), pp. 109–20, 119; and Feingold, op. cit. (48), p. 15.

57 Kocher, op. cit. (56), p. 113.

58 Thomas Blundeville, *M. Blundevile his Exercises Containing Sixe Treatises* …, London: Printed by Iohn Windet, 1594, p. 181.

59 Blundeville, op. cit. (58), p. 181.

60 Thomas Hill, *The Schoole of Skill*, London: Printed by T. Iudson, for W. Iaggard, 1599, p. 49. The text was written much earlier.

61 Hill, op. cit. (60), p. 49.

62 See Wright, op. cit. (53), pp. 534, 565. Compare also Westman, op. cit. (20), p. 590 n. 1.

63 See Westman, op. cit. (20), pp. 129–30.

standard biblical passages as literal proofs against the Earth's mobility. Mathematical practitioners supporting the heliocentric system could choose either not to discuss the Bible in the context of the Copernican physical model of the world – this seems to have been Digges's strategy, for example – or to reconcile the theory with the Scriptures, using as a primary tool the accommodation principle.

The change in the approach to biblical fragments which Kocher noted can be found in Edward Wright's address published as a preface to William Gilbert's *De Magnete* (1600). Here we can observe how the accommodation principle works:

> Nor do the passages quoted from Holy Writ appear to contradict very strongly the doctrine of the earth's mobility. It does not seem to have been the intention of Moses or the prophets to promulgate nice mathematical or physical distinctions: they rather adapt themselves to the understanding of the common people and to the current fashion of speech, as nurses do in dealing with babes.[64]

In this way, Wright suggests that biblical references to the physical world were a necessary simplification. In addition, he also reinterprets those biblical passages which were commonly cited to support the geocentric system:

> Thus, Genesis i.16 and Psalm cxxxvi. 7,9, the moon is called a great luminary, because it so appears to us, though, to those versed in astronomy, it is known that very many stars, fixed and planetary, are far larger. So, too, from Ps. civ.5, no argument of any weight can, I think, be drawn to contradict the earth's mobility, albeit it is said that God established the earth on her foundations to the end it should never be moved; for the earth may remain forevermore in its own place and in the selfsame place, in such manner that it shall not be moved away by any stray force of transference, nor carried beyond its abiding place wherein it was established in the beginning by the divine architect.[65]

Here Wright argues that people often perceive physical phenomena as they appear to them, and not as they are in reality. With reference to Psalms 104:5, Wright interprets the Earth being 'founded' as being set as steady and constant in a place pre-established by God. As we shall soon see, there are strong parallels in Gresham's and Wright's arguments for the Earth's mobility, but Gresham certainly goes further than Wright and Gilbert by openly claiming that not only does the Earth move around its axis, but it also rotates around the Sun.

Despite Wright's promising preface and John Henry's claims that Gilbert was 'evidently one of the earliest committed Copernicans', Gilbert's attitude to heliocentrism in *De Magnete* is not entirely clear.[66] Suzanne Kelly points out Gilbert's reluctance openly to state his opinion about the Earth's possible annual motion in *De Magnete*, and she states that it was 'only in the *De Mundo* that Gilbert referred to their [the

64 Edward Wright's laudatory address in William Gilbert, *On the Loadstone and Magnetic Bodies, and on the Great Magnet the Earth. A New Physiology Demonstrated with Many Arguments and Experiments* (tr. P. Fleury Mottelay), London: Bernard Quaritch, 1958, p. xlii.

65 Wright, op. cit. (64), pp. xlii–xliii.

66 John Henry, 'Animism and empiricism: Copernican physics and the origins of William Gilbert's experimental method', *Journal of the History of Ideas* (2001) 62(1), pp. 99–119, 107. On Gilbert's approach to heliocentrism see Suzanne Kelly, *The 'De Mundo' of William Gilbert*, Amsterdam: Menno Hertzberger, 1965.

planets'] revolution around the Sun'.[67] There Gilbert writes, 'The place of the Earth is in the middle, because the planets in their circular motion do not observe the Earth as a centre of motion, but the greater Sun'.[68] Moreover, Gad Freudenthal argues that Gilbert's diagram of the universe published in *De Mundo* is a proof that he had a heliocentric model in mind, since if the Sun and the planets rotated, they would penetrate the zone of the fixed stars, and there would be an observable annual parallax.[69] Freudenthal also suggests that Gilbert did not identify heliocentrism as a physical system of the world in *De Magnete*, as he failed 'to supply magnetic foundations for all celestial motions'.[70] Nonetheless, *De Magnete* definitely encouraged the advancement of science in England, leading to improvements in the description of the physical world.[71]

In this light, Gresham's approach is unique. As I shall demonstrate, not only does he devote a whole section to the reconciliation of the Copernican theory with the Bible, but apart from the predictable application of the accommodation principle in defence of heliocentrism, he also presents how the problematic passages should be read, explaining their correct meaning based on the analysis of the Hebrew Bible. It is highly likely that at the time of composing *Astrostereon* Gresham knew Gilbert's *De Magnete* and was also familiar with Wright's preface. Both Wright's address and Gresham's argumentation heavily rely on the Calvinist exegesis of the Bible. The similarities between Wright and Gresham are especially visible in three points: references to the accommodation principle, references to the apparent sizes of celestial bodies (especially the Moon), and, with regard to Earth, explaining the meaning of 'founded' as 'established' or 'constituted' by God. In order to better understand Gresham's developments of this approach, we must turn to the intricacies of such debates over Copernicanism on the Continent.

Rheticus and the Wittenberg circle

Copernicus's letter to His Holiness Pope Paul III published in *De revolutionibus* states that those who make Bible-based objections to his demonstrations are 'babblers', 'ignorant of the subject', and that they distort the true understanding of Scripture in order to criticize and censure Copernicus's work.[72] He stresses the fact that his treatise is meant for mathematicians, and he tries to mollify potential papal objections by referring to the improvements in the ecclesiastical calendar – a project he had been engaged in since the Fifth Lateran Council.[73] Copernicus did not pursue the topic of the possible

67 Kelly, op. cit. (66), p. 42, 67.

68 Compare Kelly, op. cit. (66), p. 67; and William Gilbert, *De Mundo* …, Amsterdam: Lowijs Elzevier, 1651, p. 120.

69 Gad Freudenthal, 'Theory of matter in William Gilbert's *De Magnete*', *Isis* (1983) 74(1), pp. 22–37, p. 35.

70 Freudenthal, op. cit. (69), p. 33.

71 Compare James A. Bennett, *The Mathematical Science of Christopher Wren*, Cambridge: Cambridge University Press, 2002 (first published 1982), pp. 57–60.

72 Nicholas Copernicus, *Six Books on the Revolutions of the Heavenly Spheres* (tr. Edward Rosen), Warsaw and Kraków: Polish Scientific Publishers, 1978, p. 5.

73 Compare Edward Rosen, 'Galileo's misstatements about Copernicus', *Isis* (1958) 49(3), pp. 319–30, esp. 321–3.

compatibility of his theory with the Bible in *De revolutionibus*, however. Such a task was undertaken by his only student and the earliest advocate for his ideas – Georg Joachim Rheticus.

Rheticus's claims regarding the reconciliation of Copernican theory with the Bible are presented in *De terrae motu*.[74] The existence of this short treatise, written in Latin and published anonymously only in 1651, is averted to in the letter from Tiedemann Giese to Rheticus (26 July 1543), in which the Bishop of Kulm encourages the young scholar to publish the treatise with every consecutive copy of *De revolutionibus*, because there he 'entirely correctly defended the earth's motion from being in conflict with the Holy Scriptures'.[75] The authorship of the treatise, which was printed in the Netherlands by Johannes van Waesberge, together with David Gorlaeus's *Idea Physicae*, was identified by Reijer Hooykaas in the 1970s, and convincingly demonstrated in his English edition of the text published in 1984.[76] The *De terrae motu* seems to have been designed to accompany *Narratio Prima* in the full presentation of *De revolutionibus*'s astronomical arguments. In *De terrae motu*, Rheticus advocates pious reading of biblical passages, respecting the authority of the Bible, yet allows for the accommodation principle in approaching the problematic excerpts. For example, when Rheticus refers to Joshua 10:12, Ecclesiastes 1:5, or Psalm 19, he speaks of the apparent motion of the Sun, and he says that it is 'common speech', which 'mostly follows the judgement of the senses'.[77] Earlier in the work, recounting St Augustine's understanding of a technique used in Scripture, he asserts that sometimes the Bible 'borrows a style of discourse, an idiom of speech or a method of teaching from popular usage'.[78] At the same time, Rheticus stresses the Bible's primary purpose – it is a path leading to salvation, rather than an explanation of all physical phenomena.[79]

Nienke Roelants, in her PhD dissertation 'Lutheran astronomers after the Fall: a reappraisal of the Renaissance dynamic between astronomy and religion (1540–1590)', gives a detailed analysis of Rheticus's views on the Bible. In Roelants's opinion, Rheticus shared the assumption of the primacy of Scripture in philosophical reflection in the absence of sensible impressions.[80] But, as Kenneth Howell has

74 The full printed title of the treatise reads *Epistola, Cujusdam Anonymi De Terrae Motu*. Robert Westman refers to the text as *Opusculum*; compare Westman, op. cit. (20), p. 131. Here I use the notation used in Omodeo, op. cit. (40).

75 Tiedemann Giese to Georg J. Rheticus, 26 July 1543, quoted in John Freely, *Celestial Revolutionary: Copernicus, the Man and His Universe*, London and New York: I.B. Tauris, 2014, p. 160.

76 Reijer Hooykaas, *G.J. Rheticus' Treatise on Holy Scripture and the Motion of the Earth: With Translation, Annotations, Commentary, and Additional Chapters on Ramus-Rheticus and the Development of the Problem before 1650*, Amsterdam and New York: North-Holland, 1984. The two most convincing claims are (1) the fact that the author refers to a 'Praeceptor meus' – the same phrase used by Rheticus in *Narratio Prima*, and (2) that he mentions another treatise which he wrote and in which he recounted the astronomical aspects of the heliocentric theory (a very probable reference to *Narratio Prima*).

77 Hooykaas, op. cit. (76), p. 97. The passages are discussed on pp. 95–6.

78 Hooykaas, op. cit. (76), p. 68. Compare Westman, op. cit. (20), pp. 130–1. See also Snobelen, op. cit. (34), p. 702.

79 Hooykaas, op. cit. (76), p. 71.

80 Nienke Roelants, 'Lutheran astronomers after the Fall: a reappraisal of the Renaissance dynamic between astronomy and religion (1540–1590)', PhD dissertation, Universiteit Gent, 2013, p. 244.

suggested, Rheticus was inclined to search for 'causal explanations'.[81] Rheticus's approach to Scripture made for a 'pious' exegesis, which worked alongside natural philosophy and did not hinder the development of knowledge about the surrounding world.[82] It is first alluded to in *Narratio Prima*, when Rheticus says that God equips us with various instruments and talents to deepen our knowledge of nature. This inquiry, however, should not breach limits devised by God.[83]

In order to explain the way in which the Bible is compatible with Copernicus's theory, in *De terrae motu* Rheticus refers to the passages which later form a canon in the discussion. Rheticus's exegesis of Psalms 8:4 ('When I see Thy heavens, the works of Thy fingers, the moon and the stars which Thou hast founded') rejects the possibility of reading the form 'founded' (*fundasti*) as making something immobile, because it would mean that the Moon was immobile, and 'What in heaven is more unfixed or mobile than the Moon?'[84] Rheticus immediately links it with the occurrence of the verb *fundare* in Psalms 104:5:

> Just as David said that the earth was founded, – that is, fixed and established – on its foundations, which it is to keep for ever, so we also will correctly understand the Moon, and any other moving heavenly body, to be founded and fixed, as it were, on its stability, from which it will never decline.[85]

Earth, with its co-elements, remains stable in its disposition (*ut est condita*), rather than in a physical place; it follows its due course according to God's plan.[86] Although Rheticus was educated in Wittenberg and was the professor of lower mathematics (i.e. arithmetic and geometry) there, his reading of the Bible in the manner shown above, allied with a strong belief that Copernicus's heliocentric system had a representation in a physical world, leads Robert Westman to exclude him from the so-called 'Wittenberg interpretation' of the Copernican theory.

The 'Wittenberg interpretation' is a term coined by Westman in order to describe

> a common methodological outlook or style, a consensus on how to 'read' the newly published *De revolutionibus* [1543] which was shared by a group of young astronomers at the University of Wittenberg under the fatherly tutelage of the famous Protestant reformer Philipp Melanchthon (1497–1560).[87]

The basic premise of their views was that Copernicus's theory was mathematically useful in making predictions about the angular position of planets.[88] Westman further suggests that Copernicus 'was seen, in general, as the reformer of Ptolemaic astronomy, not in a revolutionary sense, however, as later thinkers such as Kepler would believe, but in an

81 Compare Howell, op. cit. (36), pp. 60–1.

82 Compare Ann Blair, 'Mosaic physics and the search for a pious natural philosophy in the late Renaissance', *Isis* (2000) 91(1), pp. 32–58, esp. 35.

83 Georg. J. Rheticus, *Narratio Prima*, Danzig: Franz Rhode, 1540, p. 27.

84 Hooykaas, op. cit. (76), p. 94. Compare Howell, op. cit. (36), p. 65.

85 Hooykaas, op. cit. (76), p. 94.

86 Compare Howell, op. cit. (36), p. 66.

87 Robert S. Westman, 'The Melanchthon circle, Rheticus, and the Wittenberg interpretation of the Copernican theory', *Isis* (1975) 66(2), pp. 164–93, 166.

88 Compare Westman, op. cit. (87), p. 166.

essentially conservative sense, as the admired inventor of new planetary hypotheses and an improved theory of precession'.[89] From Melanchthon's published lectures, *Initia doctrinae physicae* (1549), we learn that Copernicus's new theory that the Sun stands still and the Earth moves is Aristarchus' 'old paradox' and should not be considered as it contradicts the Bible.[90] Sashiko Kusukawa has rightly observed that Melanchthon argued for the absurdity of heliocentrism much earlier, for example in a letter to Burkhard Mythobius dated 16 October 1541.[91] Therefore, although the Philippists welcomed the studies of astronomy, arithmetic and geometry as propellers of knowledge of the intricacies of God's creation and rule, they believed that those aspects of new theories which were against Scripture, or which conflicted with the acknowledged Aristotelian principles, should not be trusted or taught to students.[92] Nonetheless, the mathematical and geometrical assumptions embedded in Copernicus's theory were highly praised.[93]

The discussion led by Melanchthon and his followers concerned the connection between the World of God and the Word of God revealed in biblical writings. On a theological basis, Copernicus's theory was unacceptable to Melanchthon and his son-in-law, the professor of mathematics at Wittenberg, Caspar Peucer (1525–1602). As Robin Barnes has proposed, both Melanchthon in his *Initia doctrinae physicae* and Peucer in *Elementa doctrina de circulis coelestibus* (1551) were Christian theologians rather than natural philosophers seeking 'a thoroughly logical understanding of reality'.[94] Similarly, Peter Barker has presented the Wittenberg scholars as 'humanists with high-level astronomical competencies', capable of learned translations, but not specialists, or practitioners.[95] Their approach to nature was determined by what was manifest in Scripture. Following Luther, Melanchthon and Peucer stuck to the letter of the Bible, especially the Book of Genesis.

Both Melanchthon's *Initia* and Peucer's *Elementa* quote the standard biblical passages, i.e. Psalms 104:5; Ecclesiastes 1:4–5; Psalms 19:6–7 and Joshua 10:12. In his

89 Westman, op. cit. (87), p. 181.

90 Philipp Melanchthon, *Initia doctrina physicae*, Wittenberg: Johannes Crato, 1585 (first published 1549), p. 62. Compare Westman, op. cit. (87), p. 173.

91 Sashiko Kusukawa, *The Transformation of Natural Philosophy: The Case of Philip Melanchthon*, Cambridge: Cambridge University Press, 1995, p. 172 and n. 208.

92 Compare Westman, op. cit. (87), p. 179; Kusukawa, op. cit. (91), p. 142; and Robin B. Barnes, *Astrology and Reformation*, Oxford: Oxford University Press, 2016, p. 139. See also Pietro D. Omodeo and Jonathan Regier, 'The Wittenberg reception of Copernicus: at the origin of a scholarly tradition', in P.D. Omodeo and V. Wels (eds.), *Natural Knowledge and Aristotelianism at Early Modern Protestant Universities*, Wiesbaden: Harrassowitz Verlag, 2019, pp. 83–108, 93.

93 Westman, op. cit. (20), p. 160. See also Peter Barker, 'Kepler and Melanchthon on the biblical arguments against Copernicanism', in Van der Meer and Mandelbrote, op. cit. (34), vol. 2, pp. 585–604, 589; and Katherine Tredwell, 'The exact science in Lutheran Germany and Tudor England', unpublished PhD dissertation, University of Oklahoma, 2005, p. 135.

94 Barnes, op. cit. (92), p. 147.

95 Peter Barker, 'The role of religion in the Lutheran response to Copernicus', in Margaret J. Osler (ed.), *Rethinking the Scientific Revolution*, Cambridge: Cambridge University Press, 2000, pp. 59–88, esp. 60–1. See also Stefan Kirschner and Andreas Kühne, 'The decline of the medieval disputation culture and "The Wittenberg interpretation of the Copernican theory"', in Wolfgang Neuber, Thomas Rahn and Claus Zittel (eds.), *The Making of Copernicus: Early Modern Transformations of the Scientist and His Science*, Leiden: Brill, 2014, pp. 13–37, 37.

meticulous analysis of these passages in Melanchthon, Peucer and Kepler, Peter Barker shows the differences in the order of their presentation in the texts. As he has noted, Melanchthon's scriptural evidence against the Earth's mobility is based solely on these four passages, of which only Ecclesiastes 1:5 is given a direct reference.[96] Peucer uses almost the same arguments and wording as Melanchthon (though he presents the passages in a different order) to prove that there is no physical possibility of Earth's circular movement.[97] None of the passages are discussed in detail. According to Melanchthon, the authority of the Bible is the surest confirmation of the Earth's stability and the Sun's movement; hence the Copernican hypothesis should not be further considered as probable.[98] The same opinion is shared by Peucer.[99] However, both of these thinkers praise Copernicus as an exceptional mathematician, whose ideas might have been used to discover the secrets of the Word of God manifested in the physical world.[100]

The influence of the 'Wittenberg interpretation' extended beyond the university.[101] An important voice in the debate over the Copernican hypothesis was that of the Dane, Tycho Brahe (1546–1601) (whom Miguel A. Granada calls a 'Melanchthonian astronomer'), especially in his correspondence with Caspar Peucer and Christoph Rothmann, published as *Epistolae Astronomiae* in Uraniborg in 1596.[102] Brahe rejected Copernicus's system and eventually opted for a geo-heliocentric model of the universe, but his exchanges with Peucer and Rothmann had vital meaning for the understanding of the fluid structure of heavens and for the eventual dissolution of solid celestial spheres.[103] Rothmann's arguments in particular, reflecting his views presented in *Scriptum de cometa anni 1585*, and supporting the Copernican system, could have influenced English thinkers at the turn of the seventeenth century.[104]

As for Brahe's opinion on the biblical arguments, however, the situation is slightly more complex. As Kenneth Howell informs us, the Dane never quoted the typical biblical passages relating to the Earth's stability, although his correspondents alluded to them several times; his main argument proving the Earth's immobility was based on

96 Compare Barker, op. cit. (93), p. 590.

97 Compare Miguel A. Granada, 'Tycho Brahe, Caspar Peucer, and Christoph Rothmann on cosmology and the Bible', in Van der Meer and Mandelbrote, op. cit. (34), vol. 2, pp. 563–83, 566; and Barker, op. cit. (93), esp. pp. 592–3.

98 Compare Melanchthon, op. cit. (90), pp. 63–4.

99 Compare Caspar Peucer, *Elementa doctrinae de circulis coelestibus et primo motu*, Wittenberg: Johannes Craton, 1551, sig. G3v–4r.

100 Compare Tredwell, op. cit. (93), p. 135; and Barker, op. cit. (93), p. 589.

101 Compare Westman, op. cit. (20), p. 163.

102 Granada, op. cit. (97), p. 567.

103 See W.G.L. Randles, *The Unmaking of the Medieval Christian Cosmos, 1500–1760: From Solid Heavens to Boundless Aether*, New York: Routledge, 2004, pp. 58–63; see also Miguel A. Granada, 'Astronomy and cosmology in Kassel: the contribution of Christoph Rothmann and his relationship to Tycho Brahe and Jean Pena', *Acta historiae rerum naturalium necnon technicarum*, new series (2004) 8, pp. 244–5.

104 The text was first printed in 1619. Nonetheless, Rothmann had sent an incomplete version of the text to Brahe. The discussion of its contents was published in their correspondence (e.g. in the letters of 20 January 1587 (Brahe to Rothmann) and 21 September 1587 (Rothmann in reply to Brahe)). See Bernard R. Goldstein and Peter Barker, 'The role of Rothmann in the dissolution of the celestial spheres', *BJHS* (1995) 28, pp. 385–403, esp. 385–98.

Genesis 1:14–18.[105] Brahe's conviction that God placed the Sun, Moon and stars as signs in the firmament for time and seasons was also conveniently used by him in the context of astrology, situating stars as portents of God's decrees.[106] Both Miguel A. Granada and Kenneth Howell underline Brahe's reluctance to conduct a non-literal reading of the Bible, stressing the fact that he followed the 'Mosaic account of creation'.[107] And although Brahe knew that God's two books should be considered separately, he relied heavily on the authority of the Bible, especially with reference to geocentrism.[108]

Christoph Rothmann (1560–1600), a Wittenberg-educated mathematician and a skilled astronomer who worked at the observatory for the Landgrave Wilhelm IV of Hessen-Kassel (1532–92), was one of Brahe's correspondents who was fully convinced of the validity of the heliocentric system.[109] In order to reconcile the Copernican world view with the Bible, Rothmann applied the accommodation principle, as expressed in a letter to Brahe of 19 September 1588:

> Authority of Sacred Scripture is no obstacle. It is not written solely for me and for you, but for all men; and it speaks after their capacity of understanding, as all Theologians declare in the exposition of the first chapter of Genesis. Otherwise the moon would be, against all demonstrations of geometry, greater than all other stars … God speaks accommodating Himself to the capacity of the Hebrews.[110]

Here Rothmann makes the same reference to Genesis 1:16 regarding the real and apparent sizes of planets which, as we have already seen, was later used by Wright in his preface to Gilbert's *De Magnete*. This argument was widespread in Protestant circles, as it is based on Calvin's exegesis:

> Moses makes two great luminaries; but astronomers prove, by conclusive reasons that the star of Saturn, which on account of its great distance, appears the least of all, is greater than the moon. Here lies the difference; Moses wrote in a popular style things which without instruction, all ordinary persons, endued with common sense, are able to understand …[111]

Calvin, who did not support the Copernican system, praises in this commentary the achievements of astronomy:

105 Howell, op. cit. (36), pp. 79, 92–3. Compare Christoph Rothmann's letter of 19 September 1588, discussed below.

106 Compare Håkan Håkansson, 'Tycho the Prophet …', in Kevin Killeen and Peter J. Forshaw (eds.), *The Word and the World: Biblical Exegesis and Early Modern Science*, Basingstoke and New York: Palgrave Macmillan, 2007, pp. 137–56, 140.

107 Compare Granada, op. cit. (97), p. 573; and Howell, op. cit. (36), p. 108.

108 Compare Howell, op. cit. (36), p. 100; and Granada, op. cit. (97), pp. 579, 581.

109 See Bruce T. Moran, 'Christoph Rothmann, the Copernican theory, and institutional and technical influences on the criticism of Aristotelian cosmology', *Sixteenth Century Journal* (1982) 13(3), pp. 85–108, esp. 100–1; and Miguel A. Granada, 'Christoph Rothmann und der Copernicanismus: Die Evidenz im "Scriptum de cometa"', *Acta Historica Astronomiae* (2010) 40, pp. 35–46.

110 The Latin versions of the letters come from *Tychonis Brahe Dani Opera omnia* (ed. J.L.E. Dreyer), 15 vols., Copenhagen: Gyldendal, 1913–29 (hereafter *TBOO*), vol. 6, p. 159, ll. 19–26 (tr. Miguel A. Granada), quoted in Granada, op. cit. (97), p. 571.

111 John Calvin, *Calvin's Complete Bible Commentaries*, *The first Book of Moses called Genesis* [1554] (tr. John King [1848]), s.l., 2011, p. 72.

> For astronomy is not only pleasant, but also very useful to be known: it cannot be denied that this art unfolds the admirable wisdom of God. Wherefore, as ingenious men are to be honored who have expended useful labor on this subject, so they who have leisure and capacity ought not to neglect this kind of exercise.[112]

The premise that through the enlarged and meticulous knowledge of the world around us we increase our spiritual understanding of God has its widely discussed foundations in Romans 1:20: 'For the invisible things of him [God], that is, his eternal power and Godhead, are seen by the creation of the world' (GNV).[113] As Charles Webster has argued, the gloss on this passage in the Geneva translation of the Bible ('all men have a most cleere and evident glasse wherein to behold the everlasting and Almightie nature of God, even in his creatures') encouraged English practitioners to represent 'experimental science as a form of good works' which were a manifestation of the Calvinist doctrine of the elect.[114] According to Hooykaas, the principle of Calvin's exegesis was to make the Bible 'accessible to everybody'.[115] He further adds that the astronomers who supported the Earth's mobility and who read Calvin's commentaries (e.g. he includes Edward Wright in this group) 'would reject "biblical" arguments against their theory, with a reference to *his* [Calvin's] exegetical principles'.[116] Gresham is especially intriguing in this context, as he combines the exegetical approach (adducing meaning and applying the accommodation principle whenever necessary) with what he understands as literalistic reading of some of the problematic passages which, to his mind, were being distorted by the mistranslations and misinterpretations of the Hebrew version of the Bible.

Gresham's reconciliation of heliocentrism with the Bible

Gresham devotes the whole of Chapter 1, section 9, to the argument about the Earth's free movement. The section's subtitle reads: '*That they* [the planets] *frelie moue in space, without vection traction or expulsion of any heavens or any thinge els other then the Earth: and that the Scriptures speake nothinge againste the moveinge of the Earth and the Sun's standing still*'.[117] There are a number of different aspects of Gresham's argument to consider. The references to the Bible are spread throughout the whole text, but it is in defending the compatibility of the Copernican hypothesis

112 Calvin, op. cit. (111), p. 72. On Calvin's anti-Copernicanism see Edward Rosen, 'Calvin's attitude toward Copernicus', *Journal of the History of Ideas* (1960) 21(3), pp. 431–41, esp. 440; Richard Stauffer, 'Calvin et Copernic', *Revue de l'histoire des religions* (1971) 179(1), pp. 31–40; Reijer Hooykaas, 'Calvin and Copernicus', *Organon* (1974) 10, pp. 139–48, 140.

113 See R. Westman, 'The Copernicans and the churches', in David C. Lindberg and Ronald L. Numbers (eds.), *God and Nature: Historical Essays on the Encounter between Christianity and Science*, Berkeley, Los Angeles and London: University of California Press, 1986, pp. 76–113, esp. 95–6; and Hans Blumenberg, *The Genesis of the Copernican World* (tr. Robert M. Wallace), Cambridge, MA and London: MIT Press, 2000 (first published 1975), pp. 329–30.

114 Charles Webster, 'Puritanism, separatism, and science', in Lindberg and Numbers, op. cit. (113), pp. 203–4. See also Mason, op. cit. (54), p. 28; and Hill, op. cit. (19), p. 25.

115 Hooykaas, op. cit. (112), p. 142.

116 Hooykaas, op. cit. (112), p. 143, original emphasis.

117 Gresham, op. cit. (11), fol. 20r.

with Scripture that he is primarily focused on the Hebrew etymology, which should be 'dulie examined'.[118] His exegesis of the Bible goes beyond the verses typically quoted in the debate. Gresham embarks on a quest to access and spread the knowledge of physical truth, without undermining the authority of the Bible:

> For the written worde of veritie (which with all scruple and religion I wishe inviolable, and so respecte as the true *herculean-Stone* for the probate of all truthes), I finde nothinge thearein (rightlie understode) which maketh for the *Earth's* centrall position and stabilitie, or for the *Sun's* excentricall mobillitie.[119]

Gresham, who wholeheartedly supports the authority of the Bible by calling it the 'herculean-Stone for the probate of all truths', nonetheless rejects the literal reading of the biblical verses in the manner presented by Melanchthon or Peucer. His references to the accommodation principle are intertwined with the exegesis of the Hebrew quotations which are to secure the 'right' understanding of the problematic passages. Gresham believes the Bible to be the foundation of all truths, and in common with Wright's preface, he believes there is nothing in Scripture which would contradict the Earth's motion, but he also hastens to add that there is nothing which would support the movement of the Sun. Gresham's analysis is much broader than the four typical passages we have seen in Melanchthon and Peucer. In his reading, he primarily focuses on the two aspects mentioned by Rheticus, Rothmann and Wright: he stresses the accommodation principle and claims that the Bible speaks according to appearance.[120]

Just like his learned predecessors, Gresham observes that in many places the Bible adjusts its content to the capacity of its audience, and does not necessarily describe the nature of the world in physical terms:

> For the Sunn's mobillitie the cheifest places are Eccles. 1.5. The Sune riseth and the Sunne goeth downe and Ps. 96.6[121] his goeinge out is from the ends of the heavens, and his compasse to the end[s] of the same: fecit Lunam in tempora et sol cognovit occasum suum,[122] and many such like places. The answeare in a worde is this: that the scriptures in theis places speaketh accordinge to capacitye and apparance and not accordinge to the veritie of the thinge.[123]

In a similar manner, Gresham evokes Psalm 24, and uses an argument from physics to prove that the Bible speaks according to appearance:

> with like libertie as it appointeth the Earth's stabilitie, and foundation to be laid upon the waters *Ps. 24.2*,[124] then (which literally taken) nothing is more absurde, especiallie for the mainetenance of the Earthe's stabilitie. For fluxible and lighte things, to give foundation and formitie to stable and ponderous, is against nature, but apparantlie understoode, it is not very obsonant. For to a man at the *Seas* the maine Lande appeareth mounted from the plaine of them, as a buildinge upon a levell-grounde.[125]

118 Gresham, op. cit. (11), fol. 20v.
119 Gresham, op. cit. (11), fol. 20v.
120 Gresham, op. cit. (11), fol. 21r.
121 Should be Psalms 19:6 (GNV).
122 Psalms 104:19: 'He appointed the moon for certain seasons: the sun knoweth his going down' (GNV).
123 Gresham, op. cit. (11), fol. 21r.
124 'For he hath founded it upon the seas: and established it upon the floods' (GNV).
125 Gresham, op. cit. (11), fol. 21r.

Gresham opposes a literal reading of this passage and finds the same 'libertye of speech' in Genesis 1:16, which states that the Moon is one of the greatest lights, and groups it with Esau 13:10,[126] Ezekiel 32:8–9[127] and Joel 2:10.[128] He is concerned with the discrepancy between illusion and physical truth, and has no doubt what this physical truth is, despite the cries of 'Phantasmongers' who prefer to stay ignorant of his claims.[129] With so much emphasis laid on finding the direct correspondence between the biblical text and the physical world, Gresham does not try to explain, as Rheticus did in *De terrae motu*, that the primary aim of the Scriptures is to lead people to salvation. However, there are some similarities in their approach to the problematic biblical passages regarding the Earth's mobility.

While evoking Psalms 104:5, Gresham goes beyond the argument presented by Rheticus and Wright:

> The places seemeinge to maintayne the Earthes stabilitye are, *he set the Earthe upon her foundations, so that it shall neuer mooue*,[130] but that this maketh nothinge against the Earth's mobillitie, the *hebrew text* dulie examined maketh plaine. For the *hebrew* word תְּמוֹט[131] signifieth not to moue or goe forward but to fall, decline, slide or slippe, which (as I saide) semeth rather to confirme the *Earthe's* constancie and perpetuitie of motion in his disposition.[132]

Gresham argues that the Earth will never go astray from the course that was predetermined for it, but instead of the analysis of the Latin verb *fundare*, he refers to the Hebrew תְּמוֹט (*timot*) and to the verse's Hebrew meaning. Gresham further supports his claim by comparing Psalms 104:5 with 93:1[133] and 96:10,[134] which both use the root תָּכוֹן (*tikon*), meaning 'to be established', in the context of תְּמוֹט (*timot*). The only difference between those three psalms, Gresham assures us, is in the choice of the word תֵּבֵל (*tevel*) (universe/inhabited world) in 93:1 and 96:10 instead of אֶרֶץ (*eretz*) (earth/land) in 104:5.[135] Therefore, the 'foundations' of the Earth are connected with the globe's disposition and establishment and the phrase 'should not be moved' refers indeed to the planet's constancy.

In the final part of this argument, Gresham refers to the same concept of the Latin verb *fundare* presented by Rheticus in the analysis of Psalms 8:4 in *De terrae motu*. Gresham mixes the fragment of this verse with the Hebrew passage from Psalms 89:38: 'Lastlie if theis wordes must nedes bynde the Earth to a poste, then shall the same make the Sune

126 'For the stars of heaven and the planets thereof shall not give their light: the sun shall be darkened in his going forth, and the moon shall not cause her light to shine' (GNV).

127 '[8] All the lights of heaven will I make dark for thee, and bring darkness upon thy land, saith the Lord God. [9] I will also trouble the hearts of many people, when I shall bring thy destruction among the nations and upon the countries which thou hast not known' (GNV).

128 'The earth shall tremble before him, ye heavens shall shake, the sun and the moon shall be dark, and the stars shall withdraw their shining' (GNV). Gresham, op. cit. (11), fol. 21r.

129 Compare Gresham, op. cit. (11), fol. 20r.

130 Compare Psalms 104:5. Gresham quotes from the Geneva Bible.

131 Hebrew for 'fall', 'decline', 'collapse'; Psalms 93:1 תֵּבֵל בַּל־תִּמּוֹט ('so that the world does not fall').

132 Gresham, op. cit. (11), fol. 20v.

133 'The world also shall be established, that it cannot be moved' (GNV).

134 'Surely the world shall be stable, *and* not move' (GNV, original emphasis).

135 Gresham, op. cit. (11), fol. 21r.

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and Moone unmoveable, for stabilitie is attributed unto them as well as to the Earth Psalms 89:37 יִכּוֹן כְּיָרֵחַ[136] Lunam et stellas qua tu fundasti'.[137] Like Rheticus, Gresham tries to prove that *fundasti* cannot refer to immobility, as it would make the Moon still as well. What is more, by correlating *fundasti* with the Hebrew form *tikon*, meaning 'shall be established', he further supports his earlier claims.

From what we have already seen, Gresham's knowledge of Hebrew must have been more than cursory for him to be able to conduct such analyses. If Edward Gresham had indeed matriculated from Trinity College, Cambridge, and pursued his education there, he would have been trained in philosophy, astronomy, perspective drawing and Greek.[138] His knowledge of Hebrew might have been gained through the teachings of Edward Lively, who was a fellow at Trinity College, Cambridge, and Regius Professor of Hebrew in the years 1575–1605.[139] He was also a person known for his impressive library, comprising many volumes on astronomy and chronology, such as Prutenic tables, Peucer's *De sphaera*, Peurbach's *Theoria planetarum* or Piccolomini's *De sphaera*.[140] Some of their contents might have been included in the university lectures.

Gresham's command of Hebrew certainly goes beyond elementary knowledge, as is clear from his analyses of biblical passages presented both in *Astrostereon* and in his Prognostication for 1604. For example, when Gresham talks of Air as the primary communicator of heavenly influence and impression, he refers to *Ruah Jehovah* and *Ruah Elohim* ('the Spirit of Gods' or 'Divine Spirit'), knowing that *ruah* has the meaning of 'wind' as well.[141] Gresham explains that the 'Divine spirit' would be a better translation,

> for as in true hebraisme a singular verbe joyned to a plural nowne, doth radically intimate the whole, and the nowne derivatively distinguisheth the partiall effects of the same, as in *Bara Elohim*, *Elohim* in other places of Scripture is expounded, the Power, or Worde, or Will, or Wisdome of God, as Jerem. 10.12., Prov. 8.22., Joh. 1.3. So doth a possessive Nowne plurally or partilye used, where nature or necessitie restraineth the totall to singularitie, as here in Ruah Elohim, not Spirit of Gods, but Divine Spirit, the word Divine implying plurallitie as predictable of all attributes of Deitie.[142]

In presenting his views on the system of the world, Gresham refers to Hebrew etymology when he discusses the nature of planets as 'extinguished stars', deprived of their own light:

136 Psalms 89:37: 'He shall be established for evermore as the moon' (GNV); literally this fragment reads, 'Like the moon it shall be established'.

137 Psalms 8:4: 'the moon and the stars, which you have set in place' (translated from the Vulgate); in GNV: 'the moon and the stars which thou hast ordained'. Gresham, op. cit. (11), fol. 21r.

138 Compare Feingold, op. cit. (48), p. 41.

139 See Anthony Grafton, 'Edward Lively, cosmopolitan Hebraist', in Mordechai Feingold (ed.), *Labourers in the Vineyard of the Lord: Erudition and the Making of the King James Version of the Bible*, Leiden: Brill, 2018, pp. 82–104.

140 Feingold, op. cit. (48), p. 117.

141 Gresham uses these terms in *Astrostereon* (fol. 35r) in order to explain how divine emanations are conveyed.

142 Gresham, *A new Almanack and Prognostication for the yeere of our Lord, 1604*, London: for the assignes of J. Roberts, 1604, sig. B6v, original spelling and emphasis.

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> And for this respecte in the holye *tongue* – whose *Etymilogie* and notation is accordinge to the chiefest distinction and difference of ech *Subiect* from others so that the name of the thinge in a maner discouereth the nature thereof – they are called כּוֹכָבִים [*kochavim*, stars] of כָּבָה [*kava*, quench] signifieinge *extinguere* – to extinguishe.[143]

This search for the prelapsarian, direct correspondence of the name and the thing itself will dominate Gresham's reading of biblical passages: a strategy which helps him to reconcile Copernican cosmology with Scripture. Even if Gresham's linguistic derivations are not always grammatically justified, they are deeply rooted in Hebrew exegesis of those passages.

Whenever such etymological explanations are not enough, the second technique Gresham uses, as we have seen before, is the accommodation principle. At times, Gresham uses both of these strategies simultaneously. As in the aforementioned case with planets, common biblical quotations supporting the claim that the planets have their own light include Genesis 1:15[144] and Jeremiah 31:35.[145] To these Gresham replies, 'the Aegiptian Clarke speak accordinge to apparance (as manye thinges els shalbe prooved heareafter) for that they seemed to be luminouse bodies, whereas indede yt is the *Sun-shyne* on theire bodies that is reflected to us'.[146] Here Gresham again tells us that the Bible often relies on appearance.

The most prominent example of Gresham's double voice is his discussion of the waters above the firmament. In Chapter 1.8, in order to support his claim that planets are extinguished stars, Gresham discusses Genesis 1:2 and 2 Peter 3:6, referring to heavenly waters as a primeval state of any orb, before God's creation.[147] Gresham uses an often repeated, though somewhat skewed, etymology of the word *shamayim* (the heavens), connecting two words – *sham* (there) and *mayim* (water):

> The *Etymologie* of theire [planets'] names alludinge as it weare thereunto כּוֹכָבִים [*kochavim*, stars] of כָּבָה [*kava*, quench] – to *extinguish* or *quenche*, a thing properlie belonginge to moyster or water. The heavens themselues also κατ'εξοχήν [*kat' exochēn*, par excellence] deryveinge their notation from the outward apparance of theire contents שָׁמַיִם [*shamayim*, the heavens] as it were שם-מים *ibi aqua* – 'water there'. If this dirivation come not from שָׁמַיִם *vastum* or *angustum esse* for theire excedinge compasse.[148]

The same exegesis was presented in Caspar Peucer's letter to Tycho Brahe (10 May 1589). Peucer agreed with Tycho that the heavens were made up of 'an ethereal

143 Gresham, op. cit. (11), fol. 15r.

144 'And let them be for lights in the firmament of the heaven' (GNV).

145 'Thus saith the Lord, which giveth the sun for a light to the day, and the courses of the moon and of the stars for a light to the night' (GNV).

146 Gresham, op. cit. (11), fol. 15v.

147 In Chapter 3.3, Gresham illustrates the primeval state of planets quoting a passage from Job 38:9, in which he finds a Hebrew *paronomasia*: 'from חֻתָּלָתוֹ [*hatulato*; his garment] to הֶבֶל [*hevel*; vapor/steam] a confused Masse to a *positiue-platt*, or *habitable-plaine*'; Gresham, op. cit. (11), fol. 31r. Gresham compared the words which sounded similar in order to show their alleged connection.

148 Gresham, op. cit. (11), fol. 18v. The sources of this mistaken etymology in the early modern period lie in the simplification and misreading of certain rabbinic commentaries. See Alison Knight, 'Audience and error: translation, philology, and rhetoric in the preaching of Lancelot Andrewes', in Feingold, op. cit. (139), pp. 372–95, esp. 385–8.

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substance that is refined, pure and accessible to all rays of light and is liquid and fluid'.[149] In order to support his claim of the watery character of heavens, Peucer uses the same quasi-etymology of the Hebrew word *shamayim*, meaning 'water there'. He supports his claim by first referring to Genesis 1, where the word *rakiya* denotes a rarefied and expanded substance (and not a solid *firmamentum*). Further on, in the same letter, he evokes Genesis 8:2 ('floodgates of heavens'), Isaiah 24, Psalm 18 and Psalm 104. Brahe strongly opposed Peucer's explanation based on the semantic deconstruction of the Hebrew word, but he agrees with the exegesis of the passage from Isaiah 40:22, in which the expanded nature of the heavens (*sicut tabernaculum*) is mentioned. In a letter of 17 August 1588 to Rothmann, Brahe writes, 'I know that some theologians, following Moses – whom they understand incorrectly – claim that the heavens are made of waters; such an interpretation is denied by Philo the Jew who proves that in no degree are heavens built of elements'.[150]

For Gresham, the watery substance of heavens is not connected with actual water ('cataclismed contents thereof') but with their true substance ('the real Entitie').[151] He admits that the watery surface of the orbs can give an impression of being greater than the Earth's refraction and thus 'illudeth our eyes' that the planets shine with their own light.[152] He continues his reasoning by stating that the orbs have a lot of space in which they can move, because the water and liquified air expand and rarefy.

Eventually, Gresham states that the heavens are 'no other thinges than water and Ayer, more rarefied in ampler space'.[153] His claim that the 'watrie first attenuation' from Genesis 1:6, i.e. *rakiya* ('firmament') can be nothing else than rarefied and expanded air is supported with the passages from Isaiah 40:22 and Psalms 104:2.[154] The heavenly water and air which constitute heavens are likewise expanding, forming enough space for the planets to move freely, 'without any solid vectores or imagined circitors'.[155] In this way, through both etymological readings and references to ocular illusion, Gresham tries to reconcile the literal reading of the passages from the Book of Genesis with the theory of the air-like substance of the heavenly spheres.

The idea that the planets freely move in space was ascribed to Jean Pena (see note 103 above). Gresham might have known his preface to Euclid's *Optics* (1557), which was also reprinted in Peter Ramus's *Collectaneae, Praefationes, Epistolae, Orationes* (Marburg, 1599).[156] He might have got acquainted with it through Brahe's *Epistolae Astronomiae*, in which Rothmann discussed his theory. Many critics have suggested that Brahe was not absolutely convinced about the free movement of planets, and only having discussed the concept of fluid heavens with both Peucer and Rothmann,

149 Peucer to Brahe, 10 May 1589, *TBOO*, vol. 7, p. 185, quoted in Howell, op. cit. (36), p. 105.
150 Brahe to Rothmann, 17 August 1588, *TBOO*, vol. 6, p. 134, ll. 34–8, my translation.
151 Gresham, op. cit. (11), fol. 19r.
152 Gresham, op. cit. (11), fol. 19r.
153 Gresham, op. cit. (11), fol. 19v.
154 Gresham, op. cit. (11), fol. 19v.
155 Gresham, op. cit. (11), fol. 20r.
156 Compare Randles, op. cit. (103), p. 59.

he eventually admitted the existence of a subtle, air-like substance.[157] In *De Usu optics Praefatio*, Pena was resolved that the substance was nothing but 'the ordinary air'.[158]

Similarly, Gresham's direct sources are difficult to identify when he declines the existence of the Aristotelian sphere of fire.[159] The existence of such a sphere was first denied by Girolamo Cardano in *De subtilitate libri XXI, lib. II* (*c.*1550), but the claim was later repeated both by Pena in *De Usu*, and in Brahe's letter to Rothmann of 17 August 1588.[160] Also in this case, Gresham seems to follow Rothmann's opinion that astronomical optics disprove Aristotelian physics in the matter of the order and composition of the heavens.

In Gresham's case, straightforward associations come with difficulty; however, we might suggest that his cosmological claims and mathematical practice were formed both by his Cambridge education and by his later experience and contacts in London. Although it is only a weak assumption – if we were to look for Gresham's teachers – he might have attended Thomas Hood's mathematical lectures either at Trinity College, Cambridge (where Hood was a fellow from 1581), or in London (sometime between 1588 and 1592). However, London mathematical practitioners, such as Hood or Gunter, rarely deliberated the questions of natural philosophy. Such (infrequent) combination of a mathematical practitioner and natural philosopher was valued at princely courts and was usually a trait of the greatest thinkers of the era, such as (in England) Dee, Digges, Gilbert and Harriot.[161] The more astonishing are Gresham's statements presented in *Astrostereon*, and the greater seems the urge to further investigate the environment of late sixteenth-/early seventeenth-century London in terms of social dynamics which more often than not could reveal intricate networks of shared scientific interests, experiments and influences.

Conclusion

There is a span of sixty years between the publication of *De revolutionibus* and Gresham's *Astrostereon*. Although the early, pre-telescopic reception of Copernican thought in Europe in the period in question has been thoroughly researched, I would suggest that Gresham's attempts at the reconciliation of the Copernican theory with the Bible, and his advocacy for the free movements of planets in space, are examples

157 See Edward Rosen, 'The dissolution of the solid celestial spheres', *Journal of the History of Ideas* (1985) 46(1), pp. 13–31, 29; and Randles, op. cit. (103), p. 70. See also William H. Donahue's *The Dissolution of the Celestial Spheres*, New York: Arno Press, 1981.

158 See Randles, op. cit. (103), p. 59 n. 7.

159 'all creatures, ffeeles, sees & knowes it, namely that goodlie *Orbe* of ffyre – not the *Philosophers* foolishe *Spheare* off fyre, the ffourth Materiall Elemente, which true *Philosophie* never yet founde nor sacred Caball acknowledged, but the Sunne, that perpetuall ffounte of ffyre', Gresham, op. cit. (11), fol. 23v.

160 In *De subtilitate libri XXI*, lib. II, p. 23; see Randles, op. cit. (103), p. 61 nn. 13, 15. See also Brahe's letter to Rothmann (17 August 1588), *TBOO*, vol. 6, p. 134, ll. 29–32.

161 Compare Lesley B. Cormack, 'Handwork and brainwork: beyond the Zilsel thesis', in L.B. Cormack, S.A. Walton and John A. Schuster (eds.) *Mathematical Practitioners and the Transformation of Natural Knowledge in Early Modern Europe*, Dordrecht: Springer, 2017, pp. 11–35, 23.

of the continuity of thought in the development of astronomy and cosmology in the early modern period in Europe.[162]

As we have gathered from Gresham's text, *Astrostereon* was written as an immediate response to the accusations of spreading improbable rumour, but it is also a strong-minded attempt to present an image of the world as it is, and not as it seems to be. In order to be successful, Gresham's rhetorical techniques must have resonated with the contemporary discussion on the (im)possibility of the reconciliation of the Copernican theory with the Bible.

In search of the physical correspondence between God's two books, Gresham uses the accommodation principle in the manner of Rheticus, Rothmann or Wright, and he rejects the literal reading of the biblical passages which was proposed by the 'Mosaic philosophers' from Melanchthon's circle. For Gresham, a real literalistic reading of the Bible is in fact the 'correct' understanding of the problematic passages in Hebrew. When he gives an extensive explanation of the etymology of the Hebrew words *rakiya* and *shamayim*, he seems to be doing the same thing that Peucer does in the discussed letter to Tycho Brahe (10 May 1588), and stresses that in the Bible there is nothing against the physical world view (i.e. heliocentrism) which he supports. On the other hand, his 'literalism' ends when he analyses Job 38:22–4, and concludes that no one who is rational would claim that God indeed has a physical storage space in heaven where He could keep winds, hail and snow.[163] Gresham's literal (i.e. etymological) reading of the biblical passages is still an exegetical reading. Moreover, for those looking for correspondence between the physical world and Scripture, without recourse to the accommodation principle, the literalistic reading of the Bible would only be reading by appearances.

Kenneth Howell has observed that Copernicans 'argued, of course, that the Bible did not contain scientific content like an astronomical or physical text but, at the same time, they all believed that the truths taught in the Bible were related to and embodied in the universe'.[164] And although Howell means here the greatest, from Rheticus to Kepler and Galileo, the same paradoxical premise underlies Gresham's *Astrostereon*. Perhaps the most peculiar thing about Gresham's overt Copernicanism is the fact that he never really recalls Copernicus's work or the works of his supporters (even in England). In *Astrostereon*, he mentions Copernicus only once by name, in a passage which tells us a lot about Gresham's ego: 'most of our Prognosticators farre from the knowledge of such calculation (notwithstanding their great Instruments observinge Eclipses a yeare before they happen, a thing that neither Ptolomie, Copernicus, nor my self could ever doe)'.[165] The fact that Gresham puts himself in line with the greatest echoes the well-known concept of Renaissance self-fashioning and is a manifestation of his unfulfilled

162 Compare Peter Barker, 'The reality of Peuerbach's orbs: cosmological continuity in fifteenth and sixteenth century astronomy', in Patrick J. Boner (ed.), *Change and Continuity in Early Modern Cosmology*, Dordrecht: Springer, 2011, pp. 7–32, 9.

163 Gresham, op. cit. (11), fol. 32r.

164 Howell, op. cit. (36), p. 223.

165 Gresham, op. cit. (11), fol. 39v.

ambitions.[166] It seems that by trying to secure his place as a respected mathematical practitioner in London, Gresham also helped to propagate the heliocentric system in England.

The example of Gresham's *Astrostereon* proves that there is still much to be done in the recognition of early modern manuscript material in the context of the development of scientific thought in the late Elizabethan/early Jacobean period. What is more, it is a call to look for the traces of such data between the lines – as it seems that such debates were not necessarily brought up only in academic treatises for the elite, but also in the vernacular pamphlets, ephemera, apologies or sermons.

166 Compare Stephen Greenblatt, *Renaissance Self-Fashioning: From More to Shakespeare*, Chicago: The University of Chicago Press, 2005 (first published 1980), esp. Chapter 2.